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A study of the diatom genus Pinnularia in Iowa

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Iowa State University

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A STUDY OF THE DIATOM GENUS PINNULARIA IN IOWA

Iowa State University PH.D. 1980

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A study of the diatom genus <u>Pinnularia</u>

in Iowa

by

David Charles Jackson

A Dissertation Submitted to the

Graduate Faculty in Partial Fulfillment of the

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Iowa State University
Ames, Iowa

1980

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INTRODUCTION

Pinnularia (pinnula, a small feather) is a large genus of pennate, biraphid diatoms. Members of this genus are distributed world-wide, but are particularly abundant, both in terms of numbers of species and numbers of individuals, in waters of low pH, low mineral content, and high humate concentration (Patrick, 1948; Christensen, 1976). Hustedt (1930) states that *Pinnularia* species prefer calcium-poor waters and are often found in mountain springs and ponds as well as in springs and peaty regions of the plains. When compared with other types of diatoms, *Pinnularia* species typically comprise only a minor portion of the diatom communities present in large eutrophic inland lakes (Hustedt, 1930). In collections from high pH, hardwater habitats in Iowa, *Pinnularia* specimens usually represent less than one per cent of the total diatom population, despite the fact that a considerable number of *Pinnularia* species may be present (Christensen, 1976).

A typical *Pinnularia* cell consists of two overlapping siliceous halves or valves, the larger epivalve, and the slightly smaller hypovalve. The two valves are held together by bands of silica which are referred to as girdle bands (Plate I, Fig. 3). Intercalary bands and septae are not present. In valve view (Plate I, Fig. 1), the surfaces of the valves are visible, while in girdle view (Plate I,

Fig. 3) the girdle bands and the edges of the two valves may be seen. Cell length varies extensively among the various Pinnularia species (Patrick and Reimer, 1966). In some, the cell length may be less than 20 µm, while in others, it may exceed 350 µm (Christensen, 1976).

Plate II depicts the types of valve shapes and valve apex shapes commonly encountered in Pinnularia. The valve margins are often linear (Fig. 1) or lanceolate (Fig. 2), but somewhat convex or undulate margins also occur. The valve apices may be bluntly rounded (Fig. 3), cuneate (Fig. 4), rostrate (Fig. 5), subrostrate (Fig. 6), capitate (Fig. 7), subcapitate (Fig. 8), or other shapes.

Rows of tubular striae extend from the valve margins (Plate I, Figs. 1 and 2). Each stria consists of a "costa-like" chamber or tube which opens to the valve interior via a round or elliptical foramen (Plate I, Fig. 2). In some forms, the foramen spans the length of the stria (Plate III, Fig. 1), in others it spans only a portion of the stria (Plate III, Fig. 2). In forms where the foramen spans only a portion of the stria, the margins of the foramina are aligned to form longitudinal bands which run the length of the valve (Plate I, Figs. 1 and 2). The tubular striae communicate with the valve exterior via large numbers of minute pores (Plate III, Figs. 1 and 2).

A region which is unoccupied by striae is located along

Plate I

Valve features encountered in the genus *Pinnularia*.

Fig. 1. Valve view of *Pinnularia streptoraphe* Cl. var. *streptoraphe*.

Fig. 2. Enlarged view of the central region of a valve of *Pinnularia streptoraphe* Cl. var. *streptoraphe*.

Fig. 3. Girdle view of a *Pinnularia* species.

Abbreviations used in the figures above:

AA = axial area

CA = central area

CN = central nodule

EV = epivalve

F = foramen

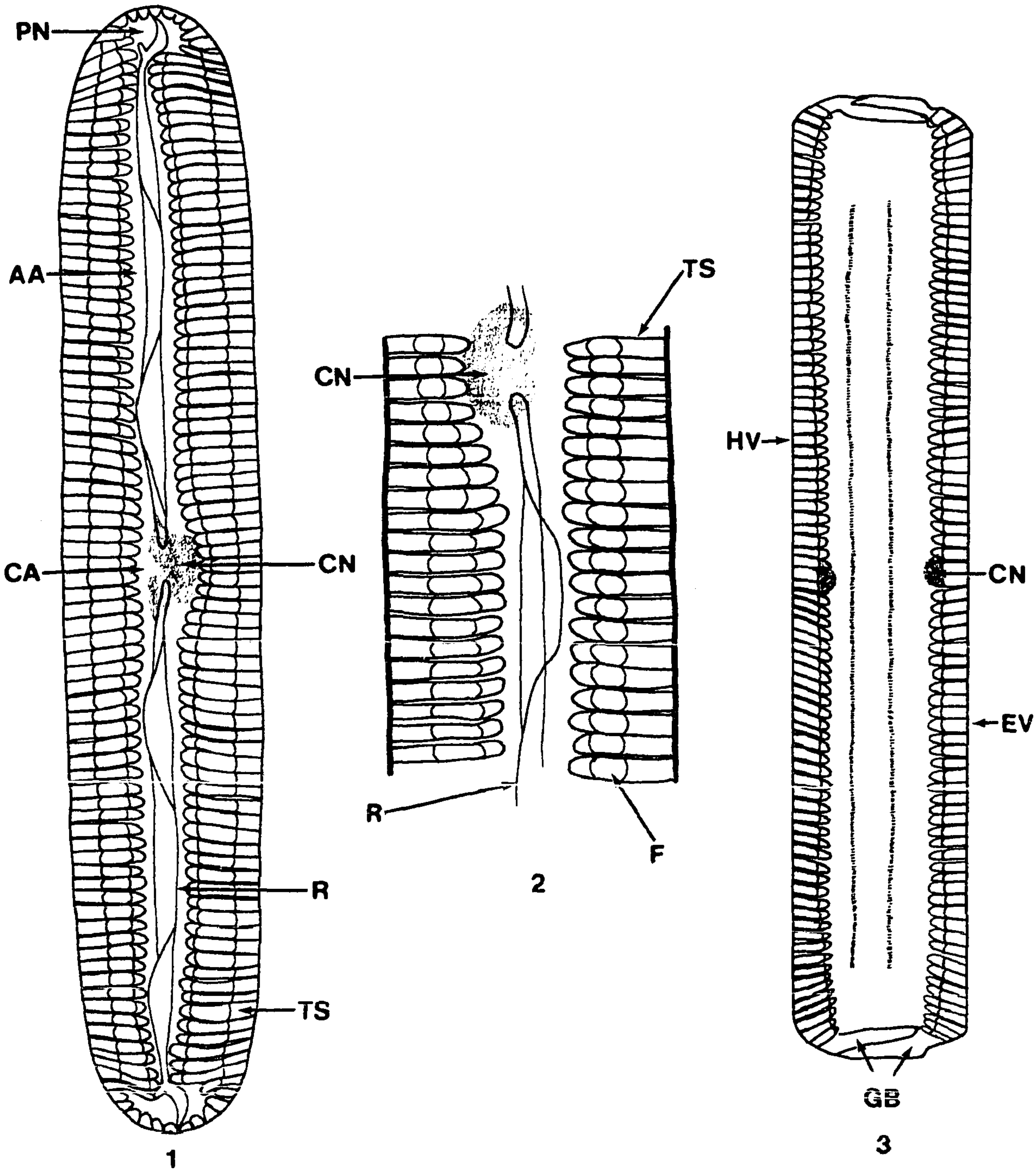
GB = girdle band

HV = hypovalve

PN = polar nodule

R = raphe

TS = tubular stria



PN
AA
CA
CN
R
TS
1
CN
TS
R
F
2
HV
CN
EV
GB
3

Plate II

Valve shapes and valve apex shapes commonly encountered in the genus *Pinnularia*.

Fig. 1. Linear valve.

Fig. 2. Lanceolate valve.

Fig. 3. Bluntly rounded valve apex.

Fig. 4. Cuneate valve apex.

Fig. 5. Rostrate valve apex.

Fig. 6. Subrostrate valve apex.

Fig. 7. Capitate valve apex.

Fig. 8. Subcapitate valve apex.

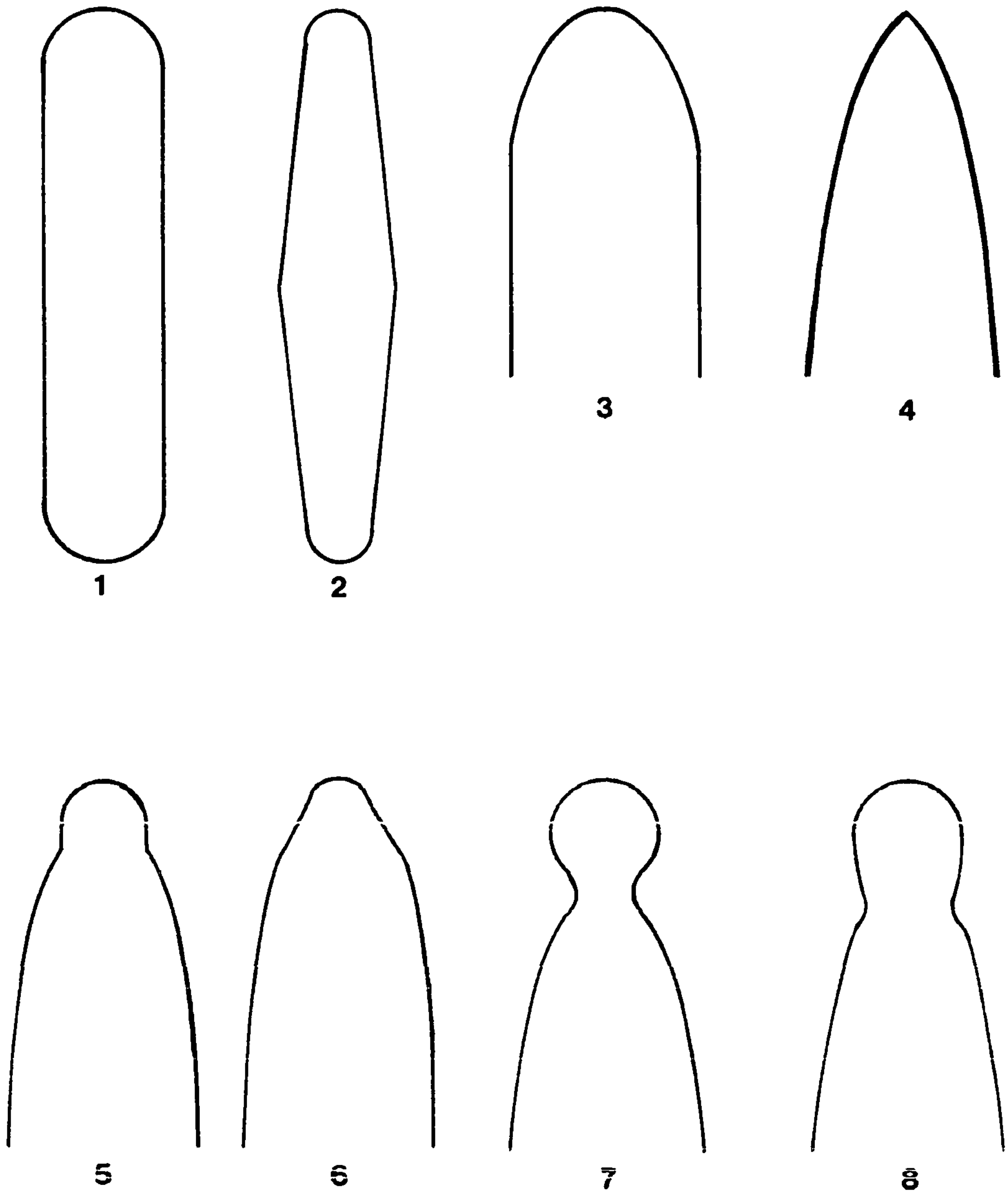

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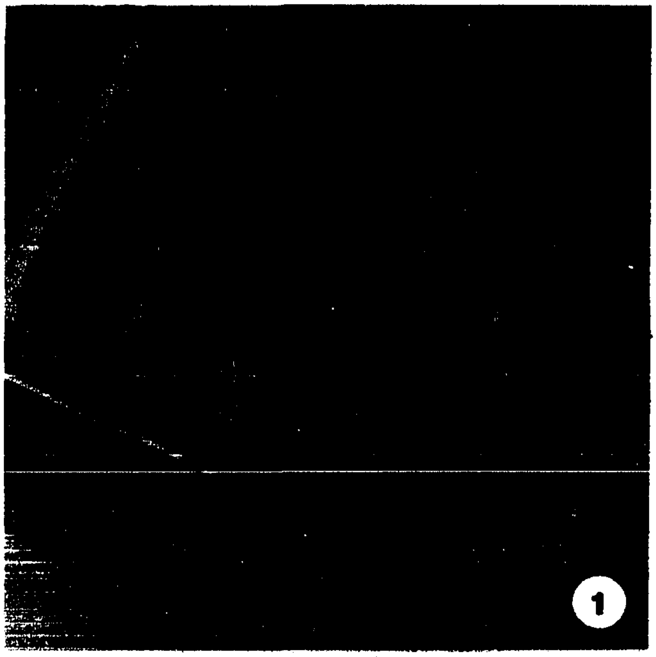
Plate III

Structure of the tubular striae in the genus <u>Pinnularia</u>.

Fig. 1. Carbon-metal replica of tubular striae in which the foramina span the length of the tubes.
X20000. TEM

Fig. 2. Carbon-metal replica of tubular striae in which the foramina span only a small portion of the length of the tubes.
X10000. TEM



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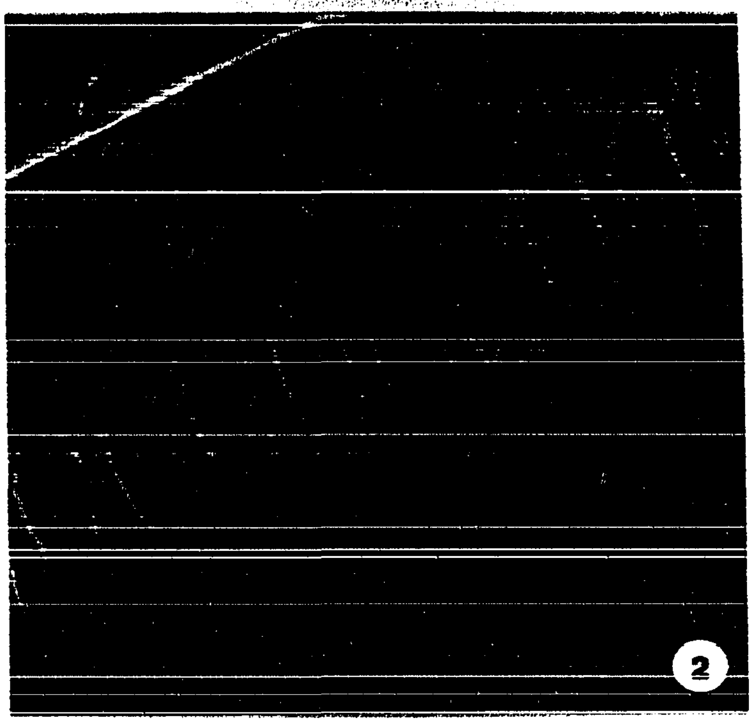

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the valve's apical (longitudinal) axis. This region is referred to as the axial area (Plate I, Fig. 1). The central area is that portion of the axial area which occupies the central region of the valve (Plate I, Fig. 1). The axial and central areas may take a variety of shapes. Occasionally, the central area extends to one or both valve margins to form a unilateral or bilateral fascia.

The raphe is a "<" shaped fissure which lies within the axial area (Plate I, Fig. 1). The "<" shape permits the sides of the valve to interlock and may serve to prevent the valve from splitting lengthwise due to osmotic pressure (Pickett-Heaps *et al.*, 1979a). In *Pinnularia* the raphe may resemble a line or band or may appear to be twisted (Patrick and Reimer, 1966). A raphe which resembles a simple line is referred to as filiform (Plate IV, Fig. 1). A band-like raphe in which two more or less parallel lines are visible is termed filamentous (Plate IV, Fig. 2). If the raphe has a somewhat wavy appearance, it is classed as undulate (Plate IV, Figs. 3 and 4). The raphe takes on a twisted appearance when the raphe fissure on the external surface of the valve weaves from side to side as it proceeds from the central area toward the valve apex. Such a raphe is designated as complex and its level of complexity may vary from very slight to very pronounced (Plate IV,

Plate IV

Raphe types and apical raphe fissure types commonly encountered in the genus *Pinnularia*.

Fig. 1. Filiform raphe.

Fig. 2. Filamentous raphe.

Fig. 3. Undulate raphe.

Fig. 4. Slightly undulate raphe.

Fig. 5. Slightly complex raphe.

Fig. 6. Moderately complex raphe.

Fig. 7. Highly complex raphe.

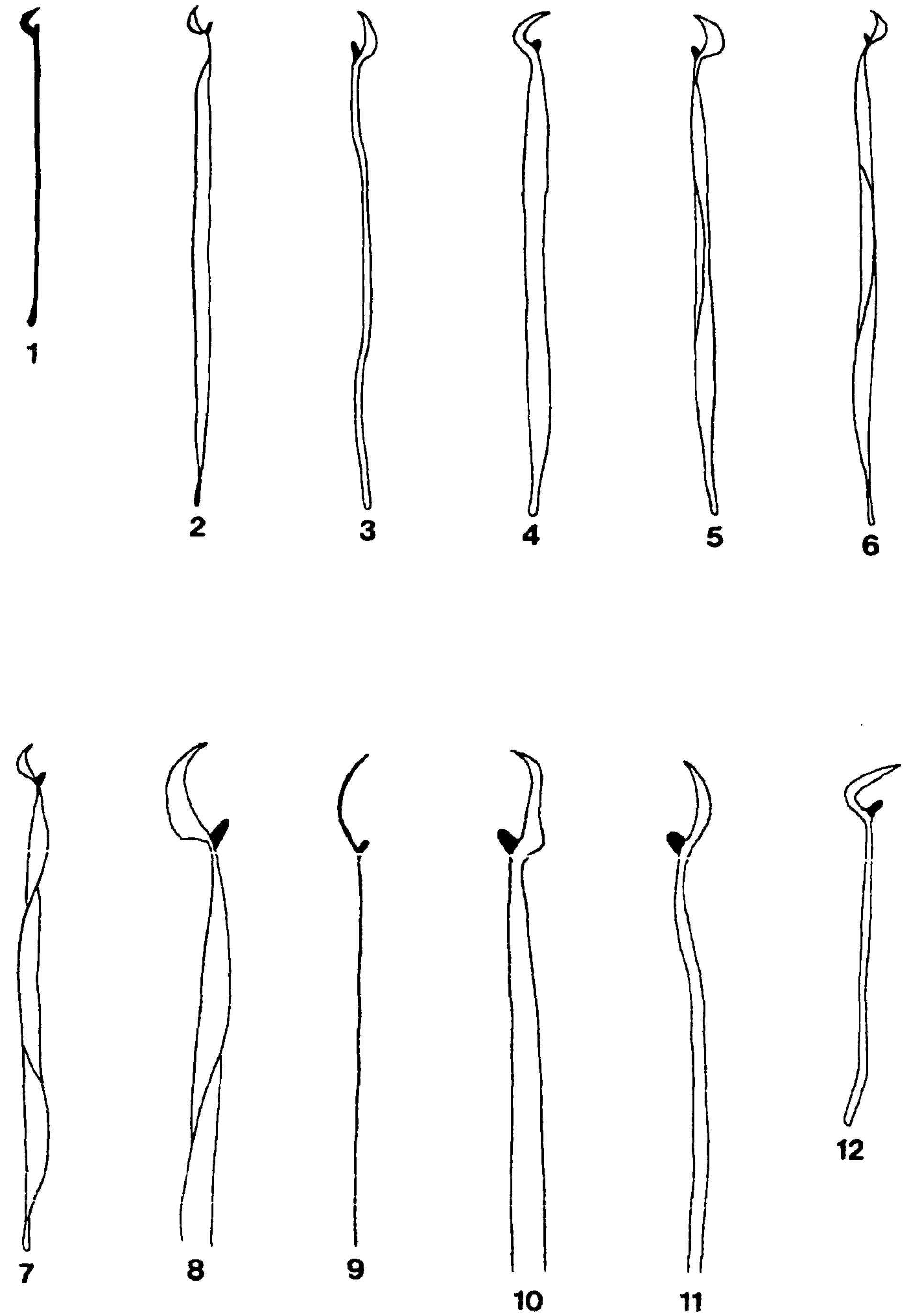
Fig. 8. "Question mark" shaped apical raphe fissure.

Fig. 9. "Comma" shaped apical raphe fissure.

Fig. 10. "Bayonet" shaped apical raphe fissure.

Fig. 11. Apical raphe fissure intermediate between "question mark" and "bayonet" shapes.

Fig. 12. "Scythe" shaped apical raphe fissure.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Figs. 5-7).

The raphe fissures at the valve apices (apical raphe fissures) may also take a variety of forms. The most frequently encountered shapes for apical raphe fissures are the "question mark" shape (Plate IV, Fig. 8), the "comma" shape (Plate IV, Fig. 9), and the "bayonet" shape (Plate IV, Fig. 10). Apical raphe fissures which are intermediate between the "question mark" and "bayonet" shapes (Plate IV, Fig. 11) or are "scythe" shaped (Plate IV, Fig. 12) do, however, occur.

The central nodule is a thickened portion of the cell wall which occurs between the median ends of the raphe (Plate I, Figs. 1-3). Due to its light-refractive properties, the central nodule often appears gray or black. The polar nodule (Plate I, Fig. 1) is an expanded hyaline region which surrounds the apical raphe fissure (Patrick and Reimer, 1966).

Based upon the criteria of valve length, breadth, and shape, number of striae per 10 μm interval of valve length, appearance of the axial and central areas, convergence and divergence of the striae, and raphe characteristics, Cleve (1895) divided the freshwater Pinnularias into eight groups. These are: Parallelistriatae, Capitatae, Divergentes, Distantes, Tabellarieae, Brevistriatae, Majores, and Complexae. These groups may be characterized as follows:

Parallelistriatae: These are predominantly small forms which frequently possess rostrate or capitate apices. The striae lie close together and are parallel or slightly radiate. The axial area may be very narrow or indistinct.

Capitatae: These are small forms possessing rostrate or capitate apices. The striae are radiate and the axial area is narrow or indistinct.

Divergentes: These forms vary in size and are linear, sublanceolate, or subelliptical in shape. The apices are rounded and the striae are strongly radiate. The breadth of the axial area is variable.

Distantes: This group is comprised of lanceolate, elliptical, or elliptic-linear forms which have broad intervals between adjacent striae.

Tabellarieae: These forms are generally narrow, linear, and somewhat swollen at the valve center and apices. The striae are typically strongly radiate near the valve center and become convergent near the apices. The apical raphe fissures tend to be "bayonet" shaped and the axial area tends to be distinct but relatively narrow.

Brevistriatae: These are linear forms with very short, parallel striae. The shortness of the striae produces a broad axial area.

Majores: Members of this group are generally large, linear forms with parallel or radiate striae and narrow axial areas. The raphe is filamentous and exhibits "question mark" shaped apical fissures.

Complexae: This group consists, generally, of large, linear forms with complex raphe structure.

Cleve (1895) recognized, however, that a great degree of variability existed within the species and groups of freshwater Pinnularias. This is evident in his statement, "The fresh-water forms pass into one another to a great extent, so that the definition of good or distinct species or groups is a matter of the greatest difficulty or almost impossible."

Hustedt (1930) retained the eight groups established by Cleve, but remarked that the groups are very closely allied and are difficult to distinguish. Hustedt also considered the concept of varieties to be of only limited value in the genus Pinnularia, due to the strong variability he observed in most of the species.

Patrick and Reimer (1966) have revised Cleve's groupings and have divided the genus into seven sections. These are: Brevistriatae, Distantes, Parallelistriatae, Capitatae, Divergentes, Maior (formerly Maiores), and Pinnularia (formerly Complexae). In this scheme, the Tabellarieae have been combined with the Divergentes.

Otherwise, the various groups and their characteristics correspond closely to those outlined by Cleve.

Pinnularia species have also been classified based upon the physical and chemical conditions of the environments where they are found. Lowe (1974) presents a summarized view of a number of spectra based upon such parameters as nutrient concentration, salt concentration, pH level, amount of current, and degree of organic pollution. These spectra are presented below:

Nutrient spectrum (after Smith, 1966):

Eutrophic: Characteristic of water with high nutrient concentrations.

Mesotrophic: Characteristic of water with moderate nutrient concentrations.

Oligotrophic: Characteristic of water with low nutrient concentrations.

Dystrophic: Characteristic of water rich in humic materials.

Current spectrum (after Hustedt, 1937; 1938a; 1938b):

Limnobiontic: Characteristic only of standing waters.

Limnophilous: Characteristic of standing water but may also occur in running water.

Current indifferent: Common in both flowing and standing water.

Rheophilous: Characteristic of running water but may also be found in standing water.

Rheobiontic: Characteristic only of running water.

Halobion spectrum (after Kolbe, 1927):

Polyhalobous: Occurring in salt concentrations above 40,000 mg/l.

Euhalobous: Marine forms, occurring in salt concentrations of 30,000 to 40,000 mg/l.

Mesohalobous: Brackish water forms, occurring in salt concentrations of 500 to 30,000 mg/l.

(alpha range - occurring in salt concentrations of 10,000 to 30,000 mg/l.)

(beta range - occurring in salt concentrations of 500 to 10,000 mg/l.)

Oligohalobous: Fresh water forms, occurring in salt concentrations of less than 500 mg/l.

(halophilous - stimulated by small quantities of salt.)

(indifferent - able to tolerate small amounts of salt.)

(halophobous - unable to tolerate even small amounts of salt.)

Euryhalobous: Occurring over a broad range of salt concentrations, often extending over two or more large spectral designations.

pH spectrum (after Hustedt, 1937; 1938a; 1938b):

Acidobiontic: Occurring at pH values below 7, with optimal pH being below 5.5.

Acidophilous: Occurring at pH values around 7, with optimal development below pH 7.

pH indifferent: Optimal development around pH 7.

Alkaliphilous: Occurring at pH values around 7, with optimal development at pH values above 7.

Alkalibiontic: Occurring only in alkaline water.

Saprobien spectrum (after Kolkwitz and Marsson, 1908):

Polysaprobic: Characteristic of the zone of degradation and putrefaction of organic pollutants, oxygen usually in low concentration or may be absent.

Mesosaprobic: Characteristic of the zone where oxidation of the organic load is occurring.

(alpha range - range of heavier pollution, nitrogen is in the form of amino acids.)

(beta range - range of lesser pollution, nitrogen is in the form of ammonia compounds.)

Oligosaprobic: Characteristic of the zone where oxidation of biodegradable compounds is complete, inorganic nutrient concentration is usually high.

Saprophilic: Usually occurring in polluted waters, but may also occur in clean water habitats.

Saproxenous: Typically occurring in clean water habitats, but may also be found in polluted waters.

Saprophobic: Characteristic of water which has not been exposed to pollutants.

The purposes of this study may be summarized as follows: 1) to identify, to as great an extent as possible, the species of *Pinnularia* which occur in Iowa, 2) to investigate the degree of variability of valve characteristics within a species, and 3) to obtain details on the fine structure of the *Pinnularia* valve utilizing electron microscopic techniques.

LITERATURE REVIEW

Ehrenberg established the genus Pinnularia in 1843. Many of the species now considered part of this genus were, however, originally placed in other genera, such as Bacillaria, Frustulia, Navicula, and Stauroptera. The original descriptions of many Pinnularia species were published by Brébisson (1838), Cleve (1891), Ehrenberg (1838; 1841; 1841 (1843)), Gregory (1856), Grunow (1876, in Schmidt et al., 1874-1959), Kützing (1833; 1844), Lagerstedt (1873), Nitzsch (1817), Smith (1853), and Van Heurck (1885).

Cleve (1895) divided the freshwater Pinnularias into eight groups based upon their size, shape, striae number, size and shape of the axial and central areas, raphe structure, and degree and direction of striae divergence. These groups were used as an organizational basis in later studies by Hustedt (1930) and Patrick and Reimer (1966).

Pinnularia species have been reported from a large number of habitats and locations in Iowa. Creeks and rivers from which Pinnularia species have been reported include the West Branch of Big Cedar Creek (Hungerford, 1971), Brewer's Creek (Edwards and Christensen, 1972), Dutch Creek (Fee, 1967), the Des Moines River (Drum, 1964; Ehrenberg, 1856; Gudmundson, 1969; 1972; Starrett and Patrick, 1952), the Mississippi River (Ehrenberg, 1856), the Raccoon River (Hungerford, 1971), and the Skunk River

(Beckert, 1977; Roeder, 1976; Shobe, 1967). *Pinnularia* species have also been found in a number of ponds, lakes, and reservoirs, including farm ponds (Ohl, 1965), Clear Lake (Begres, 1971; Myers, 1898a), the Coralville Reservoir (Schmidt and Fee, 1967), Dead Man's Lake (Christensen, 1976), Lake East Okoboji (Volker, 1963), Lake West Okoboji (Collins, 1968; Stoermer, 1963; 1964), North Twin Lake (Kutkuhn, 1958), Pillsbury and Sylvan Lake beds (Hungerford, 1972), and Big Spirit Lake (Krohn *et al.*, 1974). Other sites from which *Pinnularia* taxa have been reported include Ventura Marsh (Begres, 1971), Excelsior Fen (Shobe *et al.*, 1963), drainage tiles near Big Spirit Lake (Edwards, 1974), drainage ditches in Story County (Lowe, 1970; 1972a; 1972b), South Falls in Marion County (Stoermer, 1962), Ledges State Park (Dodd and Stoermer, 1962), the Arend's Kettle Hole (Collins, 1968), soils in the area of Iowa City (Hayek and Hulbary, 1956), soils from Cayler Prairie (Reimer, 1970), and a fossil diatomaceous deposit in Muscatine County (Myers, 1898b).

The most extensive study of *Pinnularia* in Iowa was performed by Christensen (1976), who studied the *Pinnularia* species which inhabit Dead Man's Lake. The western half of this lake is actually a *Sphagnum* bog, the existence of which was first reported in 1955 (Grant and Thorne, 1955). The physical and chemical properties of the bog and the adjacent open water region were examined by Smith and Bovbjerg (1958). Christensen reported a total of 43 *Pinnularia* taxa from this lake.

Pinnularia is a genus of world-wide distribution. *Pinnularia* species have been reported from the conterminous United States (Boyer, 1916; Patrick, 1945; Patrick and Reimer, 1966), Alaska (Mc Laughlin and Stone, 1976; Patrick and Freese, 1961), the Hawaiian Islands (Hustedt, 1942), Java (Hustedt, 1938b; 1942), Bali (Hustedt, 1938a; 1942), Sumatra (Hustedt, 1935; 1938b), the Sunda Islands (Hustedt, 1942), the Philippines (Hustedt, 1942), China (Skvortzow, 1938), and New Zealand (Harper, 1976). Species of *Pinnularia* have also been reported from Bengal (Cleve, 1895), the Belgian Congo (Hustedt, 1949), the Alps (Krasske, 1932), Switzerland (Meister, 1912), Germany (Bock, 1961; Dippel, 1904; Hustedt, 1957), Denmark (Foged, 1948; 1954), the United Kingdom (Barber, 1976; Gregory, 1856; Hare, 1978), Sweden (Cleve, 1895), Finland (Cleve, 1891; 1895; Meriläinen, 1967), Spitsbergen (Foged, 1964), and Greenland (Foged, 1972; 1973).

Cultures of two *Pinnularia* species, *P. viridis* (Nitz.) Ehr. var. *viridis* and *P. maior* var. *transversa* (A.S.) Cl., have been used in studies of cell division. In these studies, Pickett-Heaps *et al.* investigated changes in the structure of the spindle and associated organelles during successive stages of mitosis (1978a; 1978b), the structure of the cell wall (1979a), silica deposition in new cell walls following cytokinesis (1979b), and the stages of mitosis as visualized using time lapse photography and birefringence optics (1979c). Culture techniques have also been used to study the relationship between valve morphology and cell size in *Pinnularia brebissonii* (Kütz.) Rabh. var. *brebissonii* (Hostetter and Rutherford, 1976).

MATERIALS AND METHODS

The sample material used in this study was obtained from a variety of habitats in Iowa. These included lakes, streams, rivers, ponds, sloughs, fens, and bogs. In some cases, sampling locations were suggested by Dr. John Dodd; in others, they were selected by the author. Due to the large number of rivers and streams in the state, these habitats were the most heavily sampled. To facilitate sampling, the sites were chosen at points where the highways and waterways intersect. This sampling regime was designed to provide material from a variety of habitats and geographic regions in the state. Most of the samples were collected by the author during the fall of 1977 and the summer and fall of 1978. The remainder of the samples were provided by Dr. John Dodd and Mr. James Wee. A description of each sample and the locations of the various sampling sites are presented in Appendix B.

Collecting and Preserving Techniques

Diatom samples were obtained by using a small pipet to remove sediments and attached algae from the surfaces of submerged objects. The types of substrates sampled included sand and mud surfaces, rocks, sticks, and man-made objects. Occasionally, samples were obtained by squeezing moist plant material and collecting the resultant fluid as it dripped from the plants. The samples were placed in labelled 35 ml glass screw-cap vials which were subsequently placed in an ice bath for transport to the laboratory.

In the laboratory, a small portion of each sample was examined with the light microscope to determine the types of algae present and to ascertain whether the majority of the diatoms were living at the time of collection. Following this preliminary examination, one-half of each sample was preserved with Transeau's solution (6 parts water: 3 parts ethanol: 1 part commercial formalin) (Roeder, 1976).

Cleaning, Slide Preparation, and Photographic Techniques

The remaining half of each sample was diluted with distilled water and placed in a large beaker. This mixture was then boiled for approximately thirty minutes. Following boiling and decanting, the samples were "cleaned" with 30% hydrogen peroxide and potassium dichromate as described by Werff (1955). The cleaned sample was then transferred to a 250 ml beaker containing distilled water. After permitting the diatoms to settle out for approximately eight hours, the supernatant was decanted and the washing process repeated until the orange color imparted by the dichromate had disappeared. A few drops of the cleaned diatom suspension were placed on a No. 1, 18 mm square glass coverslip and allowed to air dry. The coverslip was then inverted and mounted in a drop of Hyrax mounting medium (Custom Research and Development Inc., Auburn, California) on a standard 25 mm by 75 mm glass slide. The slide was then labelled for future reference.

Specimens were examined using a Leitz Laborlux research microscope equipped with a Leica camera. Light micrographs were made using Kodak High Contrast Copy Film #5069.

Specimen Preparation for Transmission Electron Microscopy

Samples containing large numbers of Pinnularia specimens were cleaned a second time using the peroxide-dichromate method (Werff, 1955). Following several distilled water washes, the sample was soaked for twenty-four hours in a concentrated hydrochloric acid solution. Each sample was then centrifuged at 2400 r.p.m. for ten minutes in an IEC clinical centrifuge. After the acid solution had been decanted, the pellet was resuspended in distilled water and centrifuged again. This process was repeated six times with glass distilled water being used for the final three washes. These procedures were designed to remove any residual organic material as well as any acid-soluble inorganic substances.

Further specimen preparation for transmission electron microscopy followed the basic techniques outlined by Kay (1965) and Wiemers (1974). Small drops of the recleaned diatom suspension were placed on formvar-coated 100 mesh copper grids and formvar-coated 150 mesh slotted copper grids. After the suspensions had air-dried, the grids were placed in a Varian VE-30M vacuum evaporator for carbon coating. Approximately 8 mg of carbon were evaporated at a distance of 18 cm from the grids while the grids were being rotated. This process was then repeated resulting in a carbon coating approximately 170 Å thick on the specimen grids. The double carbon coating was employed to impart strength to the replicas, thereby preventing their collapse during the final stages of specimen preparation. To remove the formvar, the grids were placed in a petri dish containing chloroform-soaked filter paper for five minutes. The grids were then floated on the surface of a 7% hydrofluoric acid solution for thirty minutes. This resulted in dissolution of the diatom cell walls leaving only fragile carbon replicas of the diatoms. The grids were washed by floating them on the surface of glass distilled water and then air-dried. Next, the grids were returned to the vacuum evaporator for shadowing with a 60:40 gold:paladium alloy. The gold:paladium was evaporated at an angle of 35 degrees relative to the grid surfaces and at a distance of 8 cm from the grids. This produced a metal coating on the replicas which was approximately 30 Å thick.

A Hitachi HS-8 transmission electron microscope (TEM) was used to examine and photograph the replicas. Some of the replicas were later mounted on glass microscope slides using Hyrax mounting medium (Begres et al., 1970). This permitted examination of the replicas with the light microscope as well as with the TEM.

Specimen Preparation for Scanning Electron Microscopy

Specimen material used for scanning electron microscopy (SEM) was cleaned in the manner previously described for TEM material. The cleaned diatoms were air-dried on No. 1, 18 mm square glass coverslips. The coverslips were then coated with a thin layer of carbon (approximate thickness: 85 Å) in the vacuum evaporator. The coating was necessary to impart a degree of electrical conductivity to the specimens. The carbon-coated specimens were observed and photographed with a JEOL JSM-35 scanning electron microscope. The coverslips were later mounted on glass microscope slides using Hyrax mounting medium. This permitted observation of the specimens with the light microscope as well as with the SEM.

Determination of Valve Length, Breadth, and Striae Number of Specimens Observed with the Electron Microscope

Two methods were used to obtain the lengths, breadths, and striae numbers of specimens examined with the electron microscope. In some cases, the actual specimen or a replica of the specimen was embedded in Hyrax and measured with the light microscope. Values obtained in this manner are expressed in the plate legends as valve length (vl), valve breadth (vb), and number of striae per 10 μm interval (s/10 μm). In other cases, the length, breadth, and striae number of the specimen were estimated from micrographs. Values obtained in this manner are expressed in the plate legends as estimated valve length (evl), estimated valve breadth (evb), and estimated number of striae per 10 μm interval (es/10 μm).

RESULTS

Brevistriatae

Pinnularia acrosphaeria W. Sm. var. acrosphaeria

(Plate V)

Valves linear with slightly undulate margins, somewhat inflated at the central area and at the bluntly rounded apices (Figs. 1-9). Small specimens sometimes linear or slightly convex (Fig. 10). Length: 41-91 µm, breadth: 8-11 µm. Axial area broad and granular, one-fourth to one-half of the valve breadth. Central area asymmetric, barely wider than the axial area. Striae nearly parallel throughout most of the valve, often slightly radiate at the central area, 11-12 in 10 µm (mean: 11 in 10 µm). Longitudinal bands frequently indistinct, one-fourth to one-half of the length of the striae. Raphe filamentous (Figs. 4 and 7), often obscured by the granularity of the axial area. Apical raphe fissures differing markedly, "comma" shaped at one valve apex, "Y" shaped at the other (Fig. 7).

The carbon-metal replicas reveal the fine structure of the striae (Plate VI). Each stria consists of a tube in the cell wall which communicates with the valve exterior via a field of minute pores (Fig. 1) and with the valve interior via a foramen (Fig. 2). The "comma" and "Y" shaped apical raphe fissures are also visible (Fig. 1). The mottled appearance of the axial area of the specimen in Figure 2 may be due to uneven silica deposition in the cell wall, but this could not be verified.

Distribution: Found at only 5 locations: Dead Man's Lake (Samples #1, 3, 40, 42, 43, and 48), Carex mat near Dead Man's Lake (Sample #9), Freda Haffner Kettle Hole (Samples #25, 58, and 60), Three Corner Ponds (Sample #63), and a marsh pond near Minnewashta Lake (Sample #74).

Plate V

Valve structure and variability of *Pinnularia acrosphaeria* W. Sm. var. *acrosphaeria*. X1000. p. 29.

Fig. 1.	vl: 91 µm,	vb: 11 µm,	s/10 µm: 11.
Fig. 2.	vl: 87 µm,	vb: 10 µm,	s/10 µm: 12.
Fig. 3.	vl: 66 µm,	vb: 9 µm,	s/10 µm: 11.
Fig. 4.	vl: 65 µm,	vb: 9 µm,	s/10 µm: 11.
Fig. 5.	vl: 62 µm,	vb: 9 µm,	s/10 µm: 11.
Fig. 6.	vl: 61 µm,	vb: 9 µm,	s/10 µm: 12.
Fig. 7.	vl: 58 µm,	vb: 8 µm,	s/10 µm: 12.
Fig. 8.	vl: 56 µm,	vb: 8 µm,	s/10 µm: 11.
Fig. 9.	vl: 51 µm,	vb: 8 µm,	s/10 µm: 11.
Fig. 10.	vl: 41 µm,	vb: 8 µm,	s/10 µm: 12.

vl = valve length; vb = valve breadth; s/10 µm = number of striae per 10 µm interval

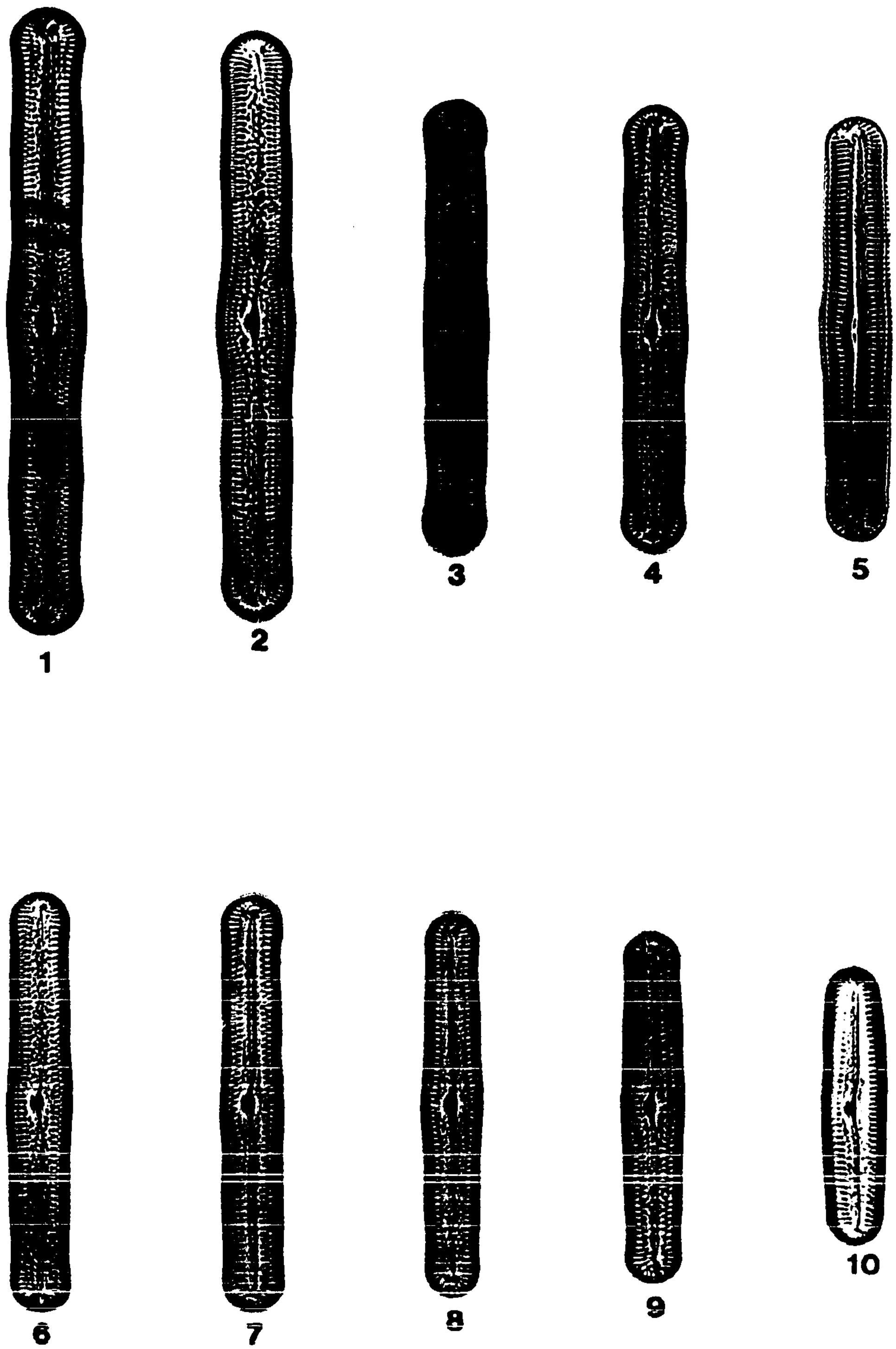
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Plate VI

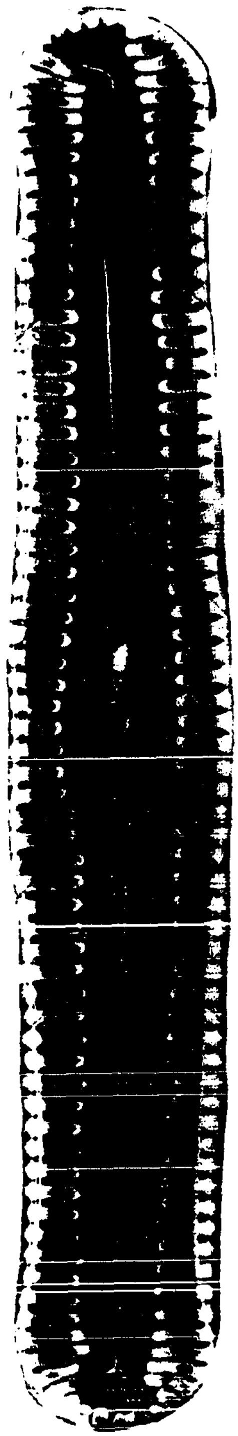
Carbon-metal replicas of
Pinnularia acrosphaeria W. Sm. var. *acrosphaeria*.

Fig. 1. *Pinnularia acrosphaeria* W. Sm. var. *acrosphaeria*.
Carbon-metal replica. X3000. TEM
evl: 63 µm, evb: 10 µm, es/10 µm: 10.

Fig. 2. *Pinnularia acrosphaeria* W. Sm. var. *acrosphaeria*.
Carbon-metal replica. X3000. TEM
vl: 57 µm, vb: 7 µm, s/10 µm: 12.

vl = valve length; vb = valve breadth; s/10 µm = number of striae per 10 µm interval

evl = estimated valve length; evb = estimated valve breadth; es/10 µm = estimated number of striae per 10 µm interval



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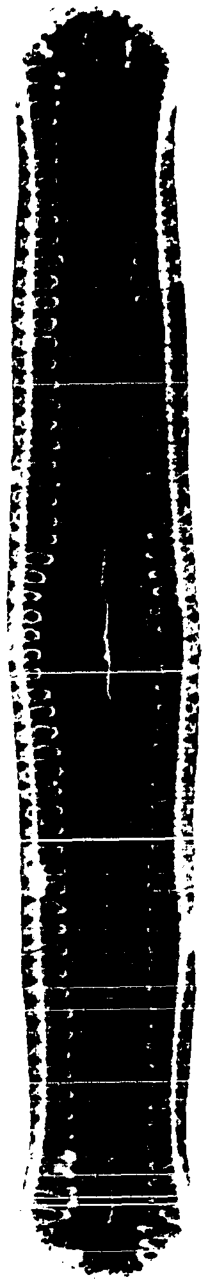

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Pinnularia brevicostata Cl. var. brevicostata

(Plate VII)

Valves linear with bluntly rounded apices. Length: 68-93 µm, breadth: 11-13 µm. Axial area broad, one-fourth to one-half of the valve breadth. Central area a narrow bilateral fascia. Striae nearly parallel throughout most of the valve, slightly radiate at the central area, parallel to slightly convergent at the apices, 9 in 10 µm. Longitudinal bands indistinct, occasionally visible near the valve margin. Raphe slightly undulate. Apical raphe fissures large, "comma" to "scythe" shaped.

Distribution: Found at only 2 locations: Freda Haffner Kettle Hole (Sample #25) and Dead Man's Lake (Samples #43 and 45). Only 5 specimens observed.

Pinnularia nodosa (Ehr.) W. Sm. var. nodosa

(Plate VIII)

Valves deeply triundulate with capitate apices. Length: 46-49 µm, breadth: 8 µm. Axial area one-fourth to one-third of the valve breadth, granular in appearance. Central area a narrow bilateral fascia. Striae radiate at the central area, convergent at the apices, 10 in 10 µm. Longitudinal bands absent. Raphe filiform, bordered by 2 dark lines. Apical raphe fissures "comma" shaped.

Distribution: Found only at Dead Man's Lake (Sample #48). Only 2 specimens observed.

Distantes

Pinnularia borealis Ehr. var. borealis

(Plate IX)

Valves linear to linear-convex with bluntly rounded or subrostrate apices. Length: 28-40 µm, breadth: 6-10 µm. Axial area one-sixth to one-third of the valve breadth. Central area variable in shape and size, often small, elliptical, and asymmetric (Fig. 3), but may form a fascia (Fig. 10). Striae parallel to slightly radiate at the central area, parallel to slightly convergent at the apices, 3-7 in 10 µm (mean: 5 in 10 µm). Longitudinal bands absent.

Plate VII

Valve structure and variability of
Pinnularia brevicostata Cl. var. *brevicostata*.
X1000. p. 34.

Fig. 1. vl: 93 µm, vb: 13 µm, s/10 µm: 9.

Fig. 2. vl: 68 µm, vb: 11 µm, s/10 µm: 9.

vl = valve length; vb = valve breadth; s/10 µm = number of striae per 10 µm interval

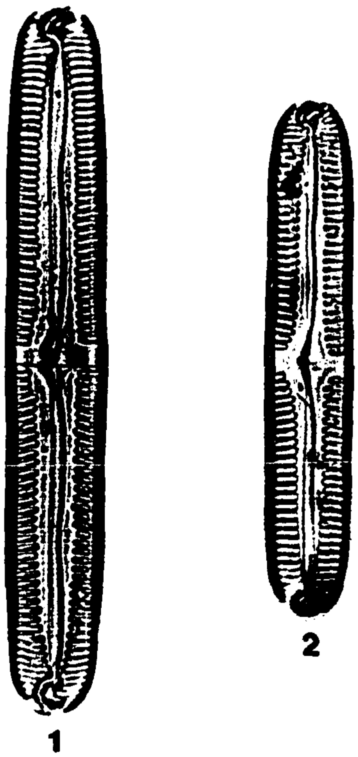
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Plate VIII

Valve structure and variability of
Pinnularia nodosa (Ehr.) W. Sm. var. *nodosa*.
X1500. p. 34.

Fig. 1. vl: 49 µm, vb: 8 µm, s/10 µm: 10.

Fig. 2. vl: 46 µm, vb: 8 µm, s/10 µm: 10.

vl = valve length; vb = valve breadth; s/10 µm = number of striae per 10 µm interval

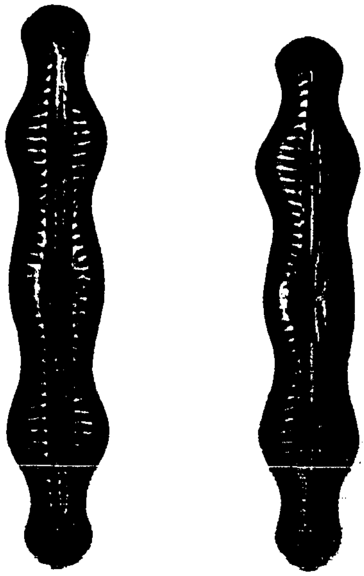

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Plate IX

Valve structure and variability of
Pinnularia _borealis_ Ehr. var. _borealis_.
X2000. p. 34.

Fig. 1.	vl: 40 µm,	vb: 8 µm,	s/10 µm: 3-4.
Fig. 2.	vl: 39 µm,	vb: 7 µm,	s/10 µm: 5-6.
Fig. 3.	vl: 38 µm,	vb: 9 µm,	s/10 µm: 5.
Fig. 4.	vl: 37 µm,	vb: 10 µm,	s/10 µm: 5.
Fig. 5.	vl: 37 µm,	vb: 8 µm,	s/10 µm: 5-6.
Fig. 6.	vl: 34 µm,	vb: 8 µm,	s/10 µm: 5.
Fig. 7.	vl: 33 µm,	vb: 8 µm,	s/10 µm: 5-6.
Fig. 8.	vl: 31 µm,	vb: 8 µm,	s/10 µm: 5.
Fig. 9.	vl: 28 µm,	vb: 7 µm,	s/10 µm: 4-5.
Fig. 10.	vl: 29 µm,	vb: 6 µm,	s/10 µm: 5.

vl = valve length; vb = valve breadth; s/10 µm = number of striae per 10 µm interval


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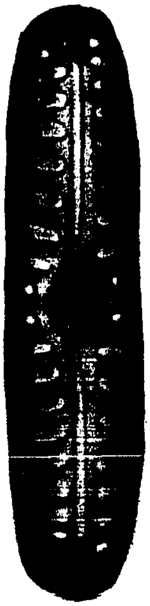
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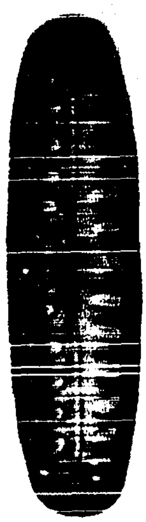
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Raphe filiform (Figs. 9 and 10) or a narrow filament (Figs. 2, 5, and 7). Apical raphe fissures "scythe" shaped (Figs. 1 and 5).

Distribution: Found at: several rivers and streams (Samples #6, 7, 24, and 138), Dead Man's Lake (Samples #1, 42, and 48), Freda Haffner Kettle Hole (Samples #25, 59, and 60), a borrow pit (Sample #33), and a pothole near Cayler Prairie (Sample #66). Only 17 specimens observed.

Pinnularia lata (Bréb.) Rabh. var. *lata*

(Plate X)

Valve linear with bluntly rounded apices. Length: 89 µm, breadth: 23 µm. Axial area one-fourth of the valve breadth. Central area large, rounded, somewhat asymmetric. Striae radiate at the central area, becoming parallel at the apices, 3 in 10 µm. Longitudinal bands absent. Raphe moderately complex. Apical raphe fissures "question mark" shaped.

Distribution: Found only at the Freda Haffner Kettle Hole (Sample #25). Only 1 specimen observed.

Parallelistriatae

Pinnularia leptosoma Grun. var. *leptosoma*

(Plate XI)

Valves linear, gradually narrowing to rounded-cuneate apices. Length: 24-40 µm, breadth: 5-6 µm. Axial area one-fifth to one-third of the valve breadth. Central area a bilateral fascia of variable size (Figs. 3, 4, and 7). Striae slightly radiate to radiate at the central area, usually parallel to slightly radiate at the apices, occasionally slightly convergent at the apices, 14-17 in 10 µm (mean: 16 in 10 µm). Longitudinal bands absent. Raphe filiform or a narrow filament. Apical raphe fissures small, "comma" shaped.

This taxon may be confused with certain species of the genus *Caloneis*. The absence of longitudinal bands on the striae indicates, however, that this taxon is probably a *Pinnularia*.

Plate X

Valve structure of
Pinnularia lata (Bréb.) Rabh. var. *lata*.
X1500. p. 41.

Fig. 1. vl: 89 µm, vb: 23 µm, s/10 µm: 3.

vl = valve length; vb = valve breadth; s/10 µm = number of striae per 10 µm interval

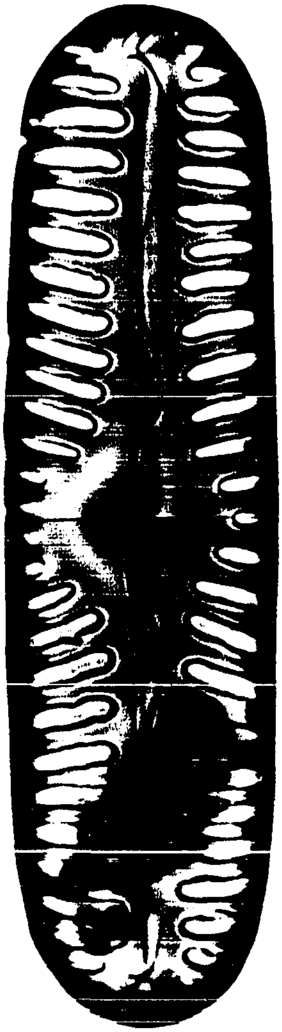
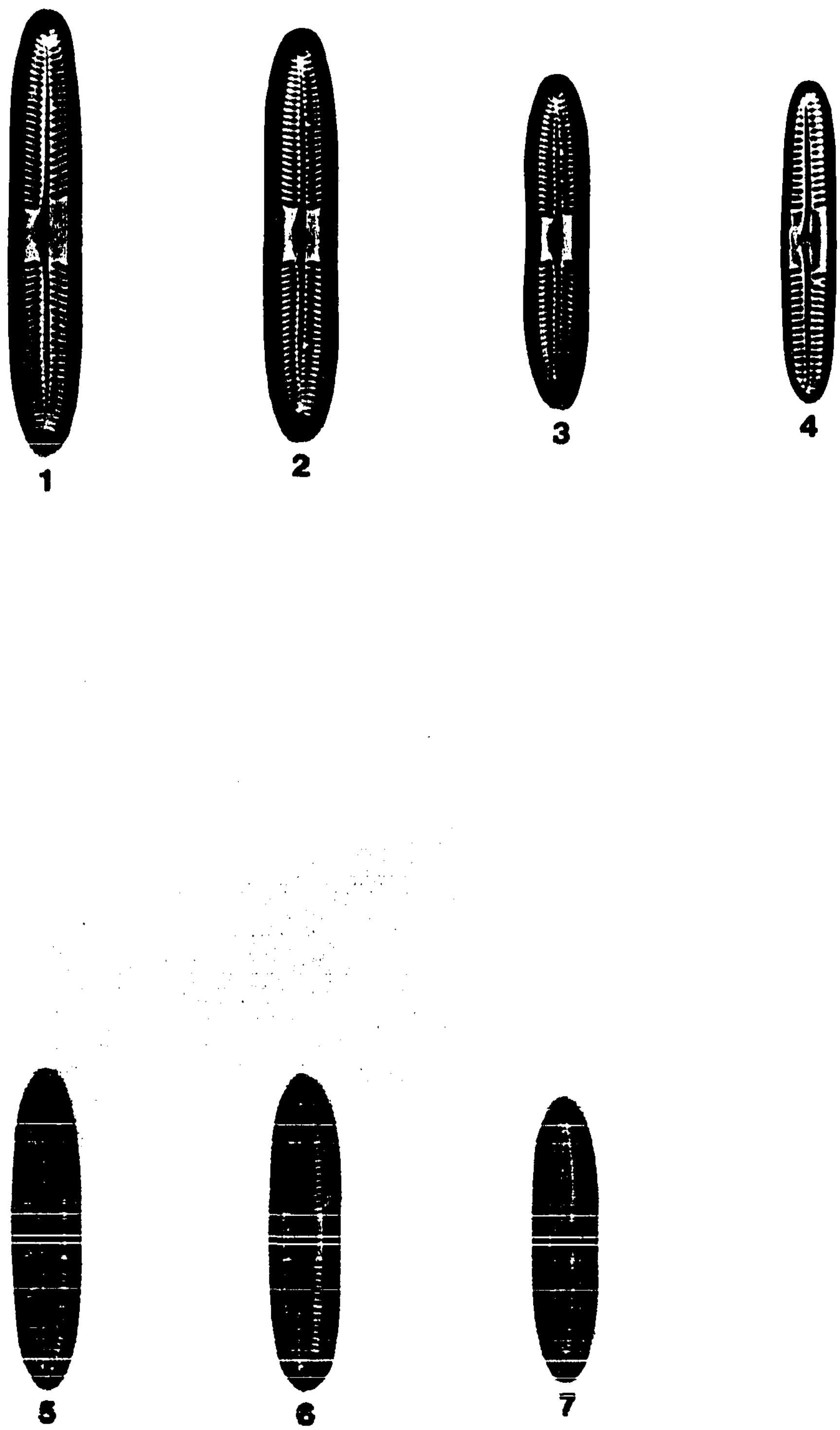


Plate XI

Valve structure and variability of
Pinnularia leptosoma Grun. var. *leptosoma*.
X1500. p. 41.

Fig. 1.	vl: 40 µm,	vb: 6 µm,	s/10 µm:	16.
Fig. 2.	vl: 37 µm,	vb: 6 µm,	s/10 µm:	17.
Fig. 3.	vl: 29 µm,	vb: 6 µm,	s/10 µm:	16.
Fig. 4.	vl: 29 µm,	vb: 5 µm,	s/10 µm:	16.
Fig. 5.	vl: 28 µm,	vb: 6 µm,	s/10 µm:	15-17.
Fig. 6.	vl: 28 µm,	vb: 6 µm,	s/10 µm:	17.
Fig. 7.	vl: 24 µm,	vb: 5 µm,	s/10 µm:	15.

vl = valve length; vb = valve breadth; s/10 µm = number of striae per 10 µm interval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Distribution: Found at 4 locations: Silver Lake Fen (Sample #22), Iowa River (Sample #30), Dead Man's Lake (Sample #44), and the Freda Haffner Kettle Hole (Samples #60, 61, and 62). Only 10 specimens observed.

Pinnularia species #1

(Plate XII)

Valves linear with rostrate to subcapitate apices. Length: 20-33 µm, breadth: 4-6 µm. Axial area one-fifth to one-half of the valve breadth, broadening gradually as it approaches the central area. Central area a bilateral fascia of variable size (Figs. 6, 9, and 12). Striae slightly radiate to radiate at the central area, becoming slightly convergent to convergent at the apices, 13-18 in 10 µm (mean: 16 in 10 µm). Longitudinal bands absent. Raphe filiform with "comma" shaped apical raphe fissures.

Distribution: Found at 5 locations: Silver Lake Fen (Samples #15 and 22), Excelsior Fen (Sample #23), Mill Creek (Sample #41), Dead Man's Lake (Sample #45), and a seepage area (Sample #55).

Capitatae

Pinnularia biceps Greg. var. *biceps*

(Plate XIII)

Valves linear, occasionally slightly convex, apices subcapitate to capitate (Figs. 1-8). Length: 49-55 µm, breadth: 9-13 µm. Axial area one-sixth to one-fourth of the valve breadth. Central area rhomboidal, expanding to form a unilateral or bilateral fascia. Striae radiate at the central area, convergent at the apices, 10-12 in 10 µm (mean: 12 in 10 µm). Longitudinal bands absent. Raphe filiform or a narrow filament. Apical raphe fissures "comma" shaped (Figs. 5 and 8).

Distribution: Found at 5 locations: Dead Man's Lake (Samples #43, 44, 45, and 46), West Lake Okoboji (Sample #57), South Fork of the English River (Sample #119), Des Moines River (Sample #134), and the West Platte River (Sample #161). Only 11 specimens observed.

Plate XII

Valve structure and variability of *Pinnularia* species #1. X2000. p. 46.

Fig. 1.	vl: 33 μm,	vb: 5 μm,	s/10 μm:	15.
Fig. 2.	vl: 30 μm,	vb: 5 μm,	s/10 μm:	15-17.
Fig. 3.	vl: 29 μm,	vb: 5 μm,	s/10 μm:	17.
Fig. 4.	vl: 28 μm,	vb: 5 μm,	s/10 μm:	17.
Fig. 5.	vl: 27 μm,	vb: 5 μm,	s/10 μm:	15.
Fig. 6.	vl: 26 μm,	vb: 5 μm,	s/10 μm:	15.
Fig. 7.	vl: 25 μm,	vb: 5 μm,	s/10 μm:	17.
Fig. 8.	vl: 24 μm,	vb: 5 μm,	s/10 μm:	15.
Fig. 9.	vl: 23 μm,	vb: 5 μm,	s/10 μm:	17.
Fig. 10.	vl: 22 μm,	vb: 5 μm,	s/10 μm:	17.
Fig. 11.	vl: 21 μm,	vb: 5 μm,	s/10 μm:	15.
Fig. 12.	vl: 20 μm,	vb: 4 μm,	s/10 μm:	17.

vl = valve length; vb = valve breadth; s/10 μm = number of striae per 10 μm interval

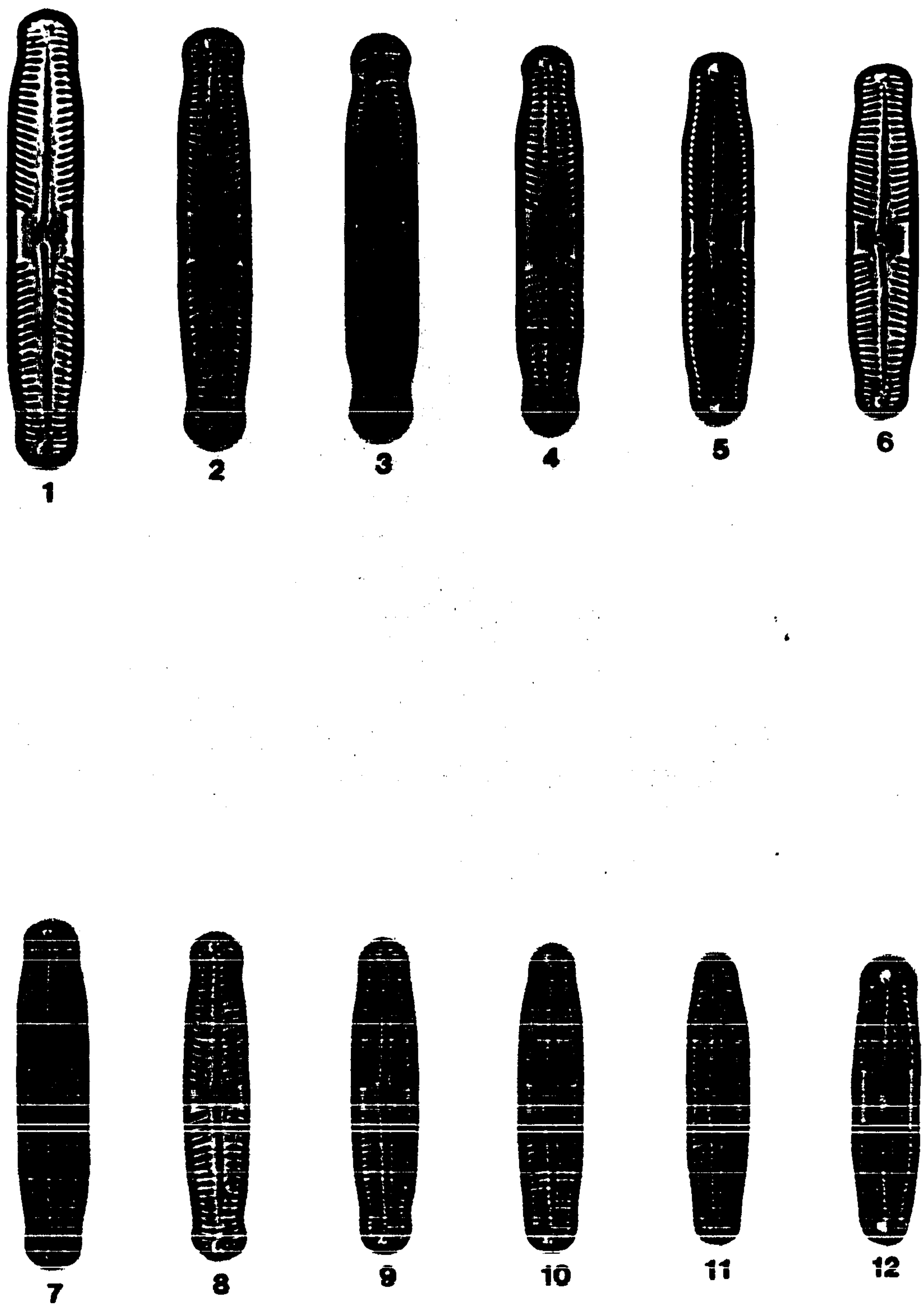
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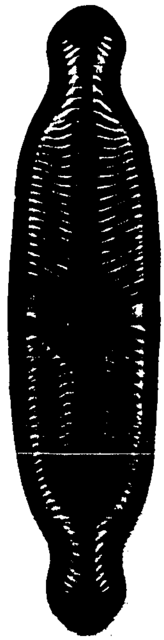
Plate XIII

Valve structure and variability of
Pinnularia biceps Greg. var. biceps.
X1500. p. 46.

Fig. 1.	vl: 55 μm,	vb: 13 μm,	s/10 μm: 11-12.
Fig. 2.	vl: 54 μm,	vb: 12 μm,	s/10 μm: 11-12.
Fig. 3.	vl: 53 μm,	vb: 12 μm,	s/10 μm: 12.
Fig. 4.	vl: 53 μm,	vb: 12 μm,	s/10 μm: 10-11.
Fig. 5.	vl: 52 μm,	vb: 13 μm,	s/10 μm: 11-12.
Fig. 6.	vl: 52 μm,	vb: 12 μm,	s/10 μm: 12.
Fig. 7.	vl: 51 μm,	vb: 12 μm,	s/10 μm: 12.
Fig. 8.	vl: 51 μm,	vb: 12 μm,	s/10 μm: 11-12.

vl = valve length; vb = valve breadth; s/10 μm = number of striae per 10 μm interval



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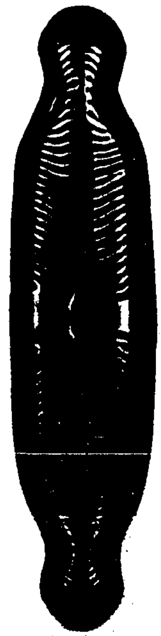

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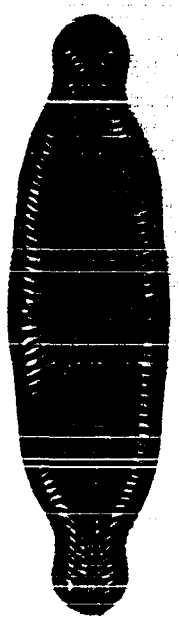

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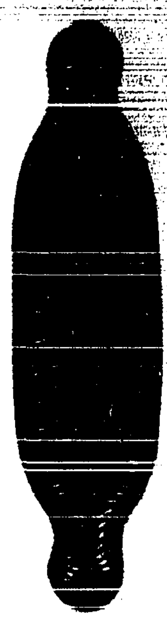

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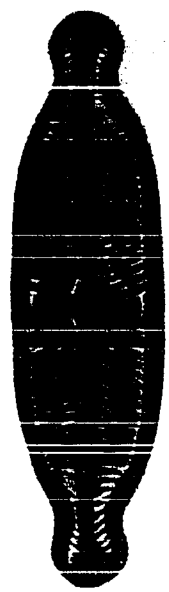

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Pinnularia braunii (Grun.) Cl. var. braunii

(Plate XIV)

Valves linear to linear-lanceolate with slightly convex (Figs. 3, 4, 5, and 7) or convex (Figs. 1, 2, 6, 8, and 9) margins. Valve apices usually capitate, occasionally subcapitate. Length: 46-56 µm, breadth: 9-11 µm. Axial area narrow at the apices, becoming progressively broader toward the central area. Central area large, elliptical (Figs. 4 and 5), a unilateral fascia (Fig. 7), or a bilateral fascia (Figs. 2 and 6). Striae radiate at the central area, convergent at the apices, 10-11 in 10 µm (mean: 10 in 10 µm). Longitudinal bands absent. Raphe a narrow filament. Apical raphe fissures "comma" shaped (Figs. 4 and 5).

The carbon replica demonstrates that the striae consist of tube-like fields of minute pores (Plate XV). The foramina appear to span the length of the tubes, resulting in the absence of longitudinal bands. One of the "comma" shaped apical raphe fissures is discernible, but the other is completely obscured.

Distribution: Found at 3 locations: Dead Man's Lake (Samples #42, 43, 44, and 45), South Fork of the Chariton River (Sample #138), and the Chariton River (Sample #139). Only 18 specimens observed.

Pinnularia interrupta W. Sm. var. interrupta

(Plate XVI)

Valves linear, occasionally slightly concave. Apices subcapitate to capitate. Length: 28-35 µm, breadth: 6-7 µm. Axial area narrow, one-seventh to one-fifth of the valve breadth. Central area somewhat rhomboidal, expanding to form a unilateral or bilateral fascia. Striae radiate at the central area, convergent at the apices, 12-15 in 10 µm (mean: 13 in 10 µm). Longitudinal bands absent. Raphe filiform with "comma" shaped apical fissures (Figs. 9 and 12).

Plate XIV

Valve structure and variability of *Pinnularia* *braunii* (Grun.) Cl. var. *braunii*. X1500. p. 51.

Fig. 1.	vl: 55 µm,	vb: 11 µm,	s/10 µm: 10-11.
Fig. 2.	vl: 55 µm,	vb: 10 µm,	s/10 µm: 11.
Fig. 3.	vl: 52 µm,	vb: 11 µm,	s/10 µm: 10.
Fig. 4.	vl: 52 µm,	vb: 10 µm,	s/10 µm: 10.
Fig. 5.	vl: 51 µm,	vb: 11 µm,	s/10 µm: 10-11.
Fig. 6.	vl: 51 µm,	vb: 9 µm,	s/10 µm: 11.
Fig. 7.	vl: 50 µm,	vb: 11 µm,	s/10 µm: 10.
Fig. 8.	vl: 50 µm,	vb: 9 µm,	s/10 µm: 11.
Fig. 9.	vl: 46 µm,	vb: 9 µm,	s/10 µm: 11.

vl = valve length; vb = valve breadth; s/10 µm = number of striae per 10 µm interval

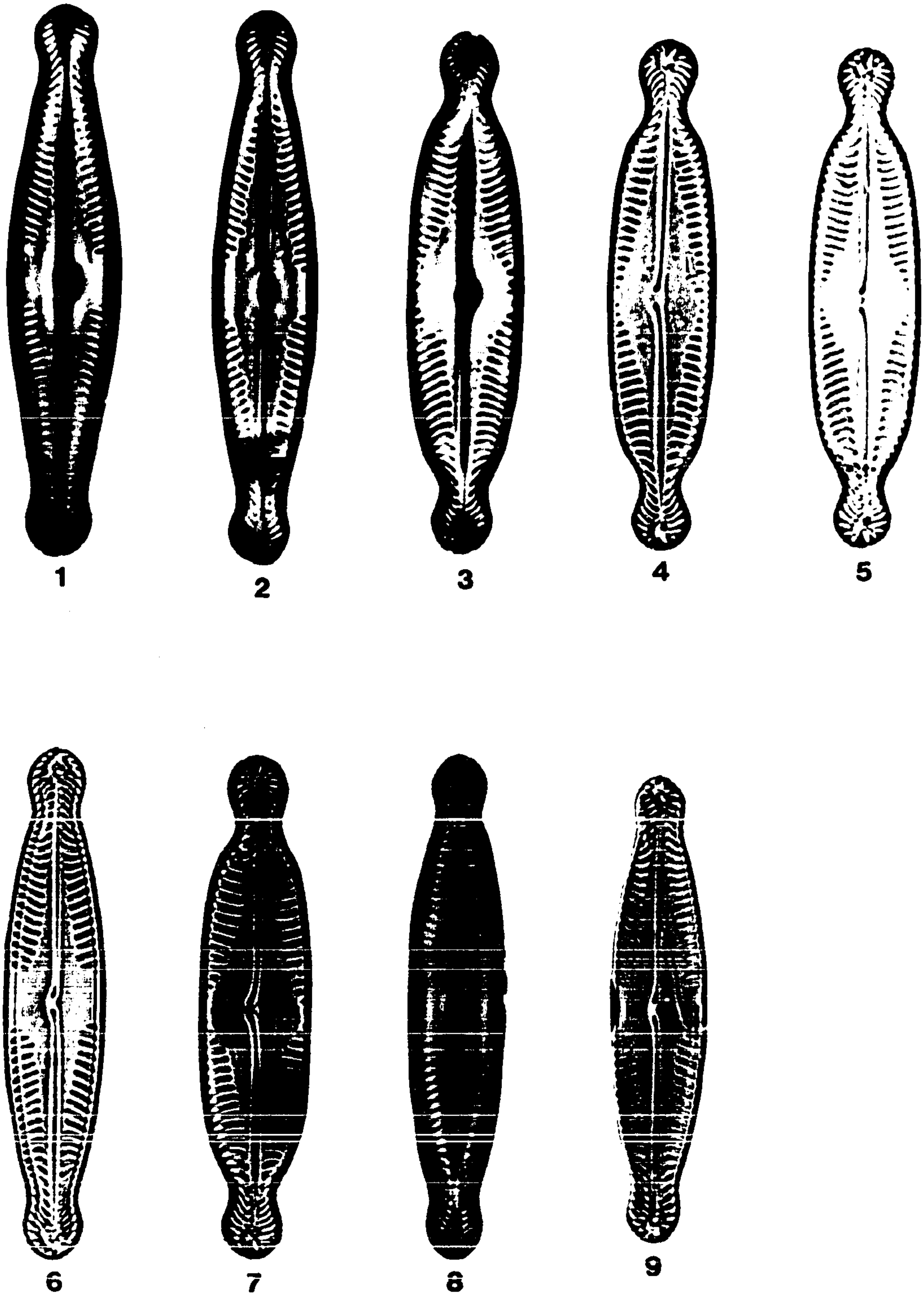
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Plate XV

Carbon-metal replica of
Pinnularia braunii (Grun.) Cl. var. *braunii*.

Fig. 1. *Pinnularia braunii* (Grun.) Cl. var. *braunii*.
Carbon-metal replica. X3000. TEM
vl: 51 µm, vb: 11 µm, s/10 µm: 11.

vl = valve length; vb = valve breadth; s/10 µm = number of striae per 10 µm interval

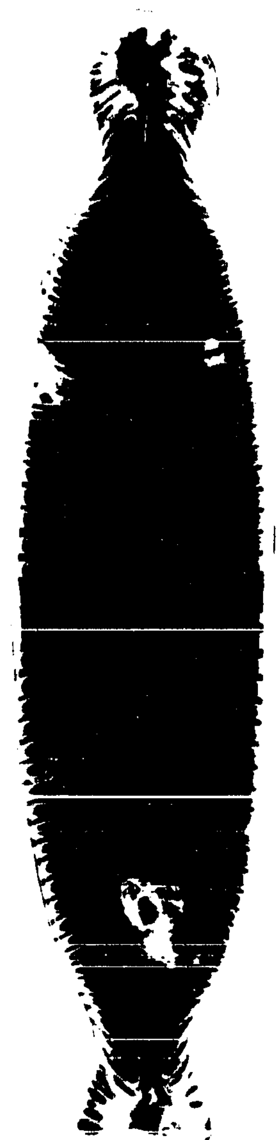
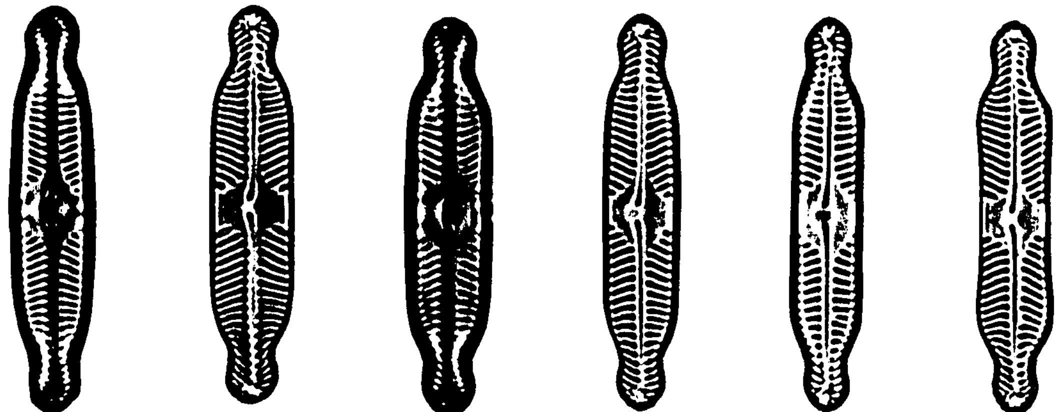


Plate XVI

Valve structure and variability of *Pinnularia interrupta* W. Sm. var. *interrupta*. X1500. p. 51.

Fig. 1.	vl: 35 µm,	vb: 7 µm,	s/10 µm:	15.
Fig. 2.	vl: 34 µm,	vb: 7 µm,	s/10 µm:	14.
Fig. 3.	vl: 34 µm,	vb: 7 µm,	s/10 µm:	13-14.
Fig. 4.	vl: 34 µm,	vb: 6 µm,	s/10 µm:	13.
Fig. 5.	vl: 34 µm,	vb: 6 µm,	s/10 µm:	13.
Fig. 6.	vl: 34 µm,	vb: 6 µm,	s/10 µm:	13.
Fig. 7.	vl: 34 µm,	vb: 6 µm,	s/10 µm:	13.
Fig. 8.	vl: 33 µm,	vb: 6 µm,	s/10 µm:	14.
Fig. 9.	vl: 33 µm,	vb: 6 µm,	s/10 µm:	14.
Fig. 10.	vl: 33 µm,	vb: 6 µm,	s/10 µm:	13.
Fig. 11.	vl: 32 µm,	vb: 6 µm,	s/10 µm:	13.
Fig. 12.	vl: 32 µm,	vb: 6 µm,	s/10 µm:	13.

vl = valve length; vb = valve breadth; s/10 µm = number of striae per 10 µm interval



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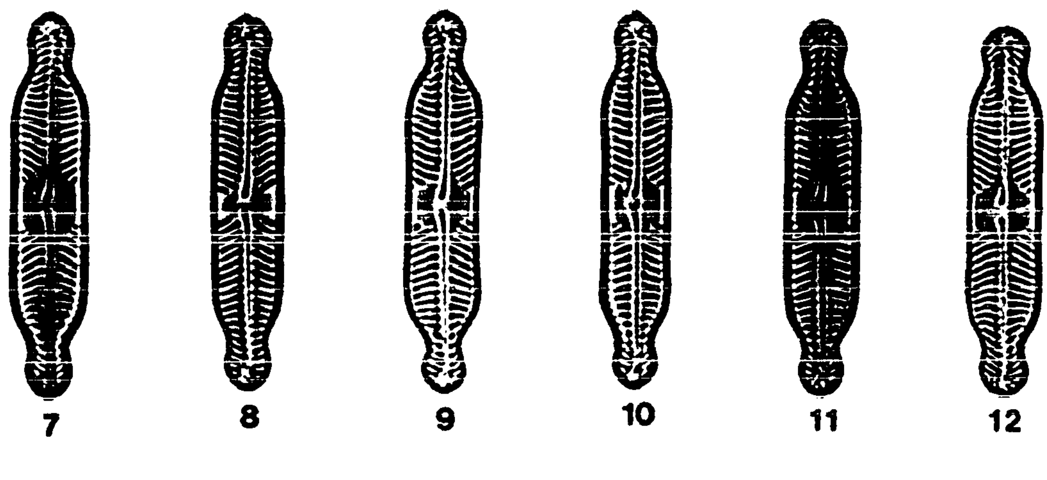


7 8 9 10 11 12

Plate XVII

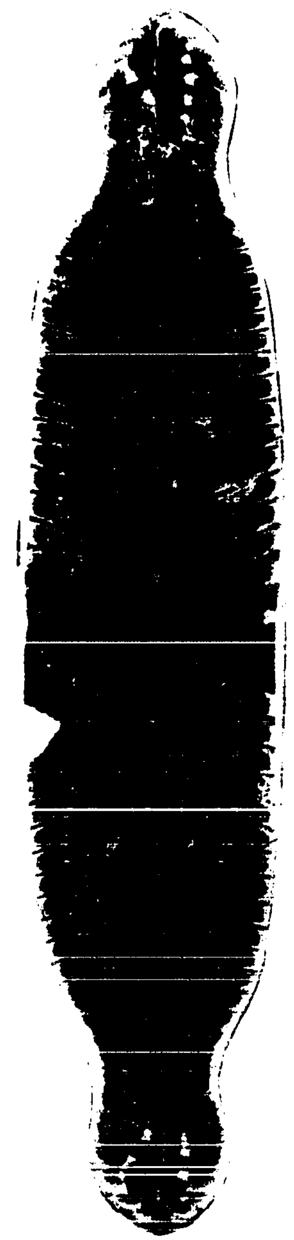
Carbon-metal replicas of
Pinnularia interrupta W. Sm. var. _interrupta_.

Fig. 1. _Pinnularia interrupta_ W. Sm. var. _interrupta_.
Carbon-metal replica. X5000. TEM
vl: 32 µm, vb: 6 µm, s/10 µm: 14.

Fig. 2. _Pinnularia interrupta_ W. Sm. var. _interrupta_.
Carbon-metal replica. X5000. TEM
evl: 32 µm, evb: 7 µm, es/10 µm: 15.

vl = valve length; vb = valve breadth; s/10 µm = number of striae per 10 µm interval

evl = estimated valve length; evb = estimated valve breadth; es/10 µm = estimated number of striae per 10 µm interval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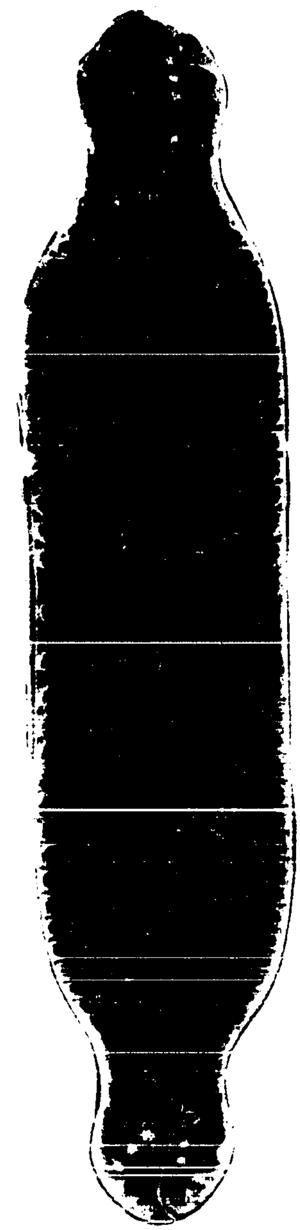
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The carbon-metal replicas reveal that the tubular striae are covered with masses of small pores (Plate XVII). No longitudinal bands appear on either replica. The "comma" shaped apical raphe fissures are apparent in Figure 2. These replicas are very similar to those of *Pinnularia mesolepta*, but have linear valve margins rather than the undulate margins typical of *P. mesolepta*.

Distribution: Found at 2 locations: Dead Man's Lake (Samples #42, 43, 44, 45, 47, and 48) and the Freda Haffner Kettle Hole (Samples #60 and 61).

Pinnularia mesolepta fo. *angusta* Cl.

(Plate XVIII)

Valves triundulate (Figs. 1 and 2), biundulate (Figs. 15 and 16), or almost linear (Figs. 13 and 14). Valve apices frequently rostrate, but ranging from subrostrate to subcapitate. Length: 23-56 μm, breadth: 5-7 μm. Axial area one-sixth to one-third of the valve breadth. Central area typically a bilateral fascia, but may be a unilateral fascia or a hyaline elliptical space. Striae slightly radiate to radiate at the central area, slightly convergent to convergent at the apices, 9-12 in 10 μm (mean: 11 in 10 μm). Longitudinal bands absent. Raphe filiform or a narrow filament. Apical raphe fissures "comma" shaped (Figs. 2 and 3).

In two of the three carbon-metal replicas (Plate XIX, Figs. 1 and 3), the porous siliceous plates which form the outer surfaces of the tubular striae have been eroded away leaving a series of slot-like openings in the cell walls. In Figure 2, the porous plates have remained intact and no longitudinal bands are evident.

Distribution: Found at 4 locations: Dead Man's Lake (Samples #1, 3, 40, 42, 43, and 48), *Carex* mat near

Plate XVIII

Valve structure and variability of
<u>Pinnularia</u> <u>mesolepta</u> fo. <u>angusta</u> Cl.
X1500. p. 60.

Fig. 1.	vl: 56 µm,	vb: 7 µm,	s/10 µm:	9.
Fig. 2.	vl: 54 µm,	vb: 6 µm,	s/10 µm:	9-10.
Fig. 3.	vl: 48 µm,	vb: 6 µm,	s/10 µm:	10.
Fig. 4.	vl: 44 µm,	vb: 6 µm,	s/10 µm:	10.
Fig. 5.	vl: 43 µm,	vb: 6 µm,	s/10 µm:	10.
Fig. 6.	vl: 40 µm,	vb: 6 µm,	s/10 µm:	10.
Fig. 7.	vl: 37 µm,	vb: 6 µm,	s/10 µm:	10.
Fig. 8.	vl: 36 µm,	vb: 6 µm,	s/10 µm:	11.
Fig. 9.	vl: 35 µm,	vb: 6 µm,	s/10 µm:	10.
Fig. 10.	vl: 34 µm,	vb: 6 µm,	s/10 µm:	10.
Fig. 11.	vl: 32 µm,	vb: 6 µm,	s/10 µm:	10.
Fig. 12.	vl: 30 µm,	vb: 6 µm,	s/10 µm:	12.
Fig. 13.	vl: 29 µm,	vb: 6 µm,	s/10 µm:	11.
Fig. 14.	vl: 27 µm,	vb: 6 µm,	s/10 µm:	11-12.
Fig. 15.	vl: 26 µm,	vb: 6 µm,	s/10 µm:	10.
Fig. 16.	vl: 23 µm,	vb: 5 µm,	s/10 µm:	11.

vl = valve length; vb = valve breadth; s/10 µm = number of striae per 10 µm interval

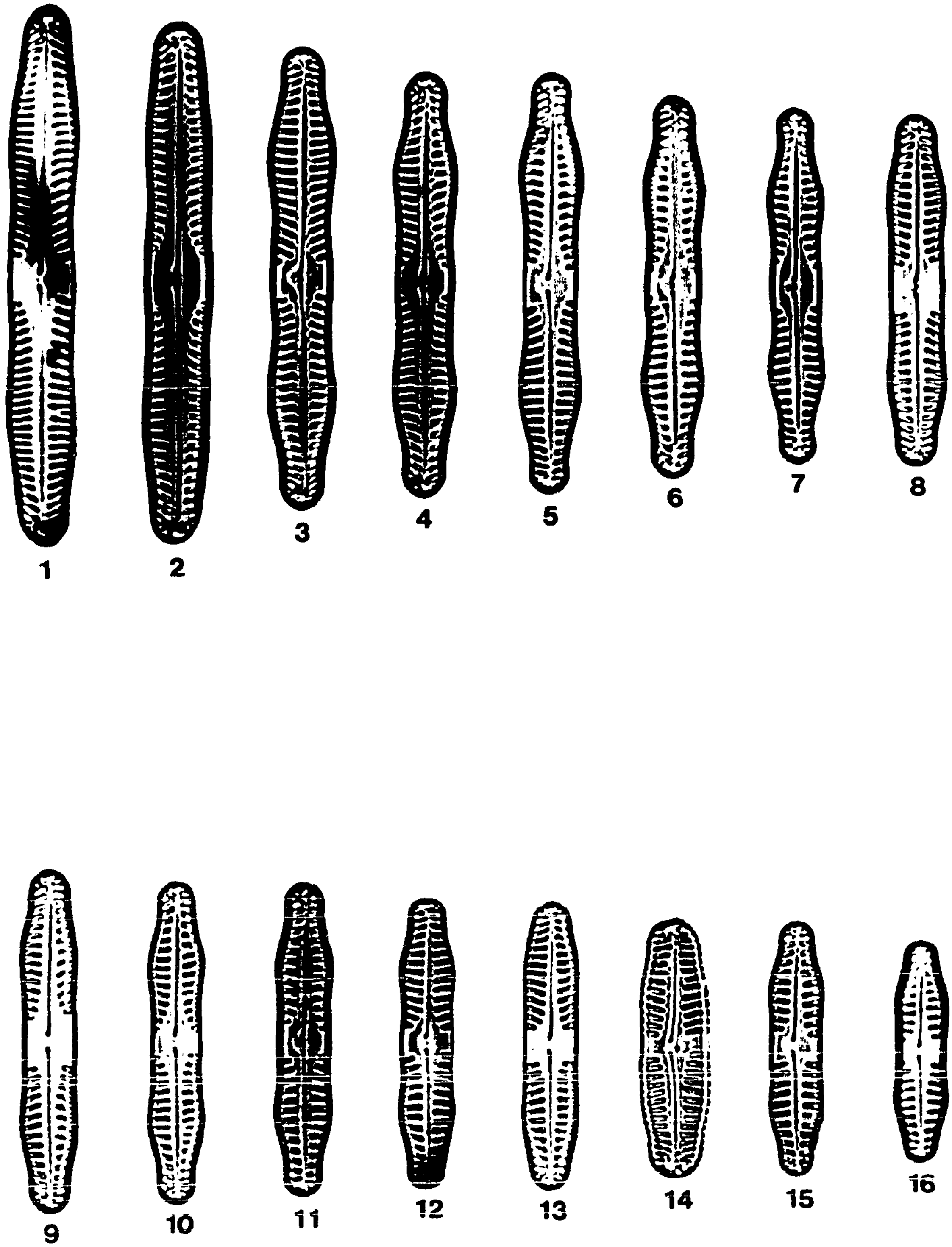
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Plate XIX

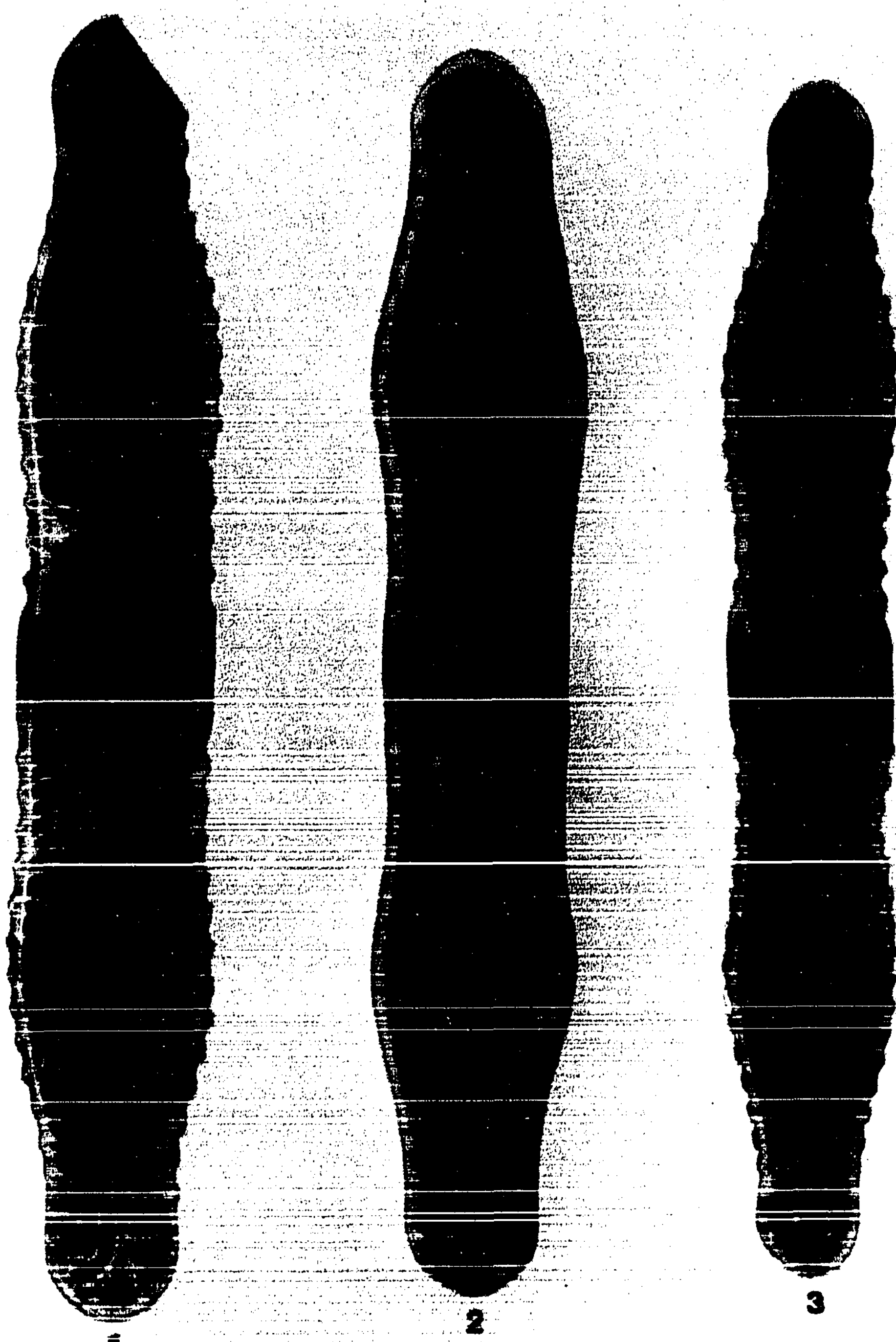
Carbon-metal replicas of
Pinnularia _mesolepta_ fo. _angusta_ Cl.

Fig. 1. _Pinnularia_ _mesolepta_ fo. _angusta_ Cl.
Carbon-metal replica. X5000. TEM
vl: 35 µm, vb: 6 µm, s/10 µm: 11.

Fig. 2. _Pinnularia_ _mesolepta_ fo. _angusta_ Cl.
Carbon-metal replica. X5000. TEM
vl: 32 µm, vb: 5 µm, s/10 µm: 10-11.

Fig. 3. _Pinnularia_ _mesolepta_ fo. _angusta_ Cl.
Carbon-metal replica. X4000. TEM
vl: 41 µm, vb: 6 µm, s/10 µm: 10.

vl = valve length; vb = valve breadth; s/10 µm = number of striae per 10 µm interval



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Dead Man's Lake (Sample #9), Dugout Creek (Sample #24), and a pothole near Cayler Prairie (Sample #66).

<u>Pinnularia mesolepta</u> (Ehr.) W. Sm. var. <u>mesolepta</u>

(Plate XX)

Valves triundulate, central undulation sometimes subtle. Apices subcapitate to capitate. Length: 27-37 µm, breadth: 6-7 µm. Axial area one-seventh to one-fourth of the valve breadth. Central area a bilateral fascia, occasionally a unilateral fascia. Striae radiate at the central area, slightly convergent to convergent at the apices, 11-14 in 10 µm (mean: 13 in 10 µm). Longitudinal bands absent. Raphe filiform with "comma" shaped apical fissures (Figs. 1 and 6).

The carbon-metal replicas (Plate XXI) show the porous structure of the tubular striae. The foramina appear to nearly span the lengths of the striae, resulting in the absence of longitudinal bands. The "comma" shaped apical raphe fissure is visible in Figure 3. These replicas are very similar to those of <u>Pinnularia interrupta</u>, but have slightly undulate valve margins rather than the linear margins typical of <u>P</u>. <u>interrupta</u>.

<u>Distribution</u>: Found at 3 locations: Dead Man's Lake (Samples #1, 40, 42, 43, 44, 45, 46, 47, and 48), Freda Haffner Kettle Hole (Samples #25, 59, 60, and 62), and Mill Creek (Sample #41).

<u>Pinnularia subcapitata</u> Greg. var. <u>subcapitata</u>

(Plate XXII)

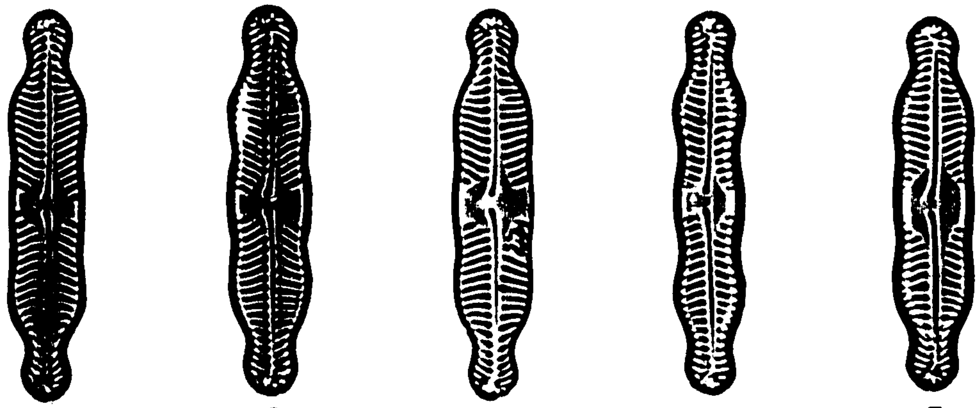
Valves linear, slightly convex, or somewhat lanceolate. Apices rostrate, occasionally subrostrate or subcapitate. Length: 16-48 µm, breadth: 4-7 µm. Axial area one-fifth to one-third of the valve breadth. Central area usually a bilateral fascia, occasionally a unilateral fascia.

Plate XX

Valve structure and variability of
Pinnularia mesolepta (Ehr.) W. Sm. var. *mesolepta*.
X1500. p. 65.

Fig. 1.	vl: 35 μm,	vb: 6 μm,	s/10 μm:	12.
Fig. 2.	vl: 34 μm,	vb: 7 μm,	s/10 μm:	13.
Fig. 3.	vl: 34 μm,	vb: 6 μm,	s/10 μm:	13.
Fig. 4.	vl: 33 μm,	vb: 6 μm,	s/10 μm:	12-13.
Fig. 5.	vl: 32 μm,	vb: 7 μm,	s/10 μm:	13.
Fig. 6.	vl: 32 μm,	vb: 6 μm,	s/10 μm:	13-14.
Fig. 7.	vl: 31 μm,	vb: 6 μm,	s/10 μm:	13-14.
Fig. 8.	vl: 31 μm,	vb: 6 μm,	s/10 μm:	12.
Fig. 9.	vl: 30 μm,	vb: 6 μm,	s/10 μm:	11.
Fig. 10.	vl: 29 μm,	vb: 6 μm,	s/10 μm:	13.

vl = valve length; vb = valve breadth; s/10 μm = number of striae per 10 μm interval



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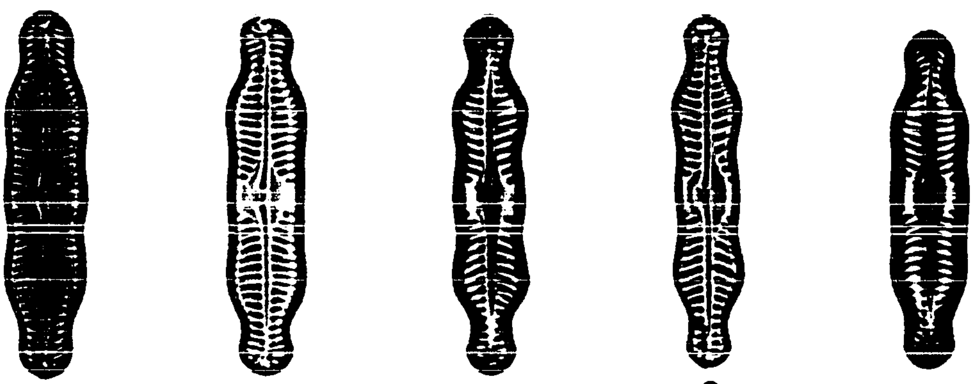

6 7 8 9 10

Plate XXI

Carbon-metal replicas of
Pinnularia mesolepta (Ehr.) W. Sm. var. *mesolepta*.

Fig. 1. *Pinnularia mesolepta* (Ehr.) W. Sm. var. *mesolepta*.
Carbon-metal replica. X6000. TEM
vl: 31 µm, vb: 6 µm, s/10 µm: 14.

Fig. 2. *Pinnularia mesolepta* (Ehr.) W. Sm. var. *mesolepta*.
Carbon-metal replica. X3000. TEM
evl: 32 µm, evb: 6 µm, es/10 µm: 12.

Fig. 3. *Pinnularia mesolepta* (Ehr.) W. Sm. var. *mesolepta*.
Carbon-metal replica. X3000. TEM
vl: 33 µm, vb: 6 µm, s/10 µm: 14.

vl = valve length; vb = valve breadth; s/10 µm = number of striae per 10 µm interval

evl = estimated valve length; evb = estimated valve breadth; es/10 µm = estimated number of striae per 10 µm interval

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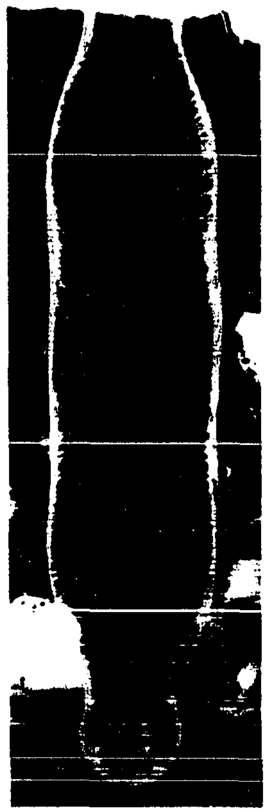


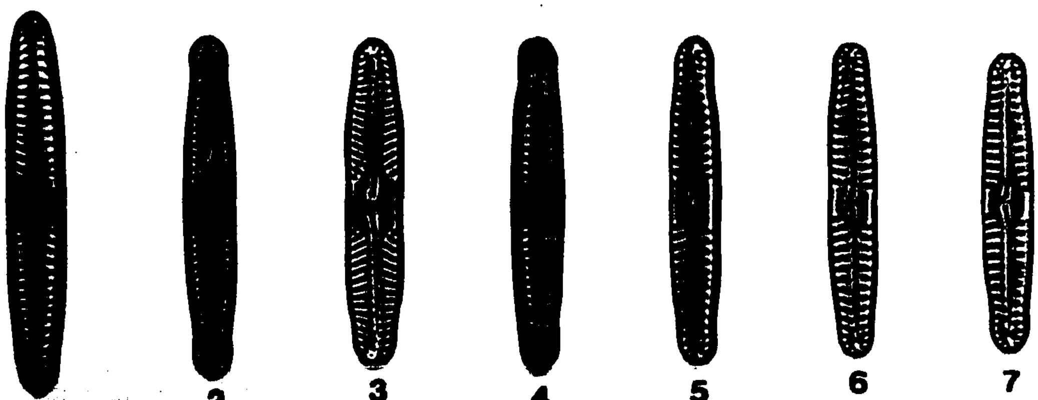
3

Plate XXII

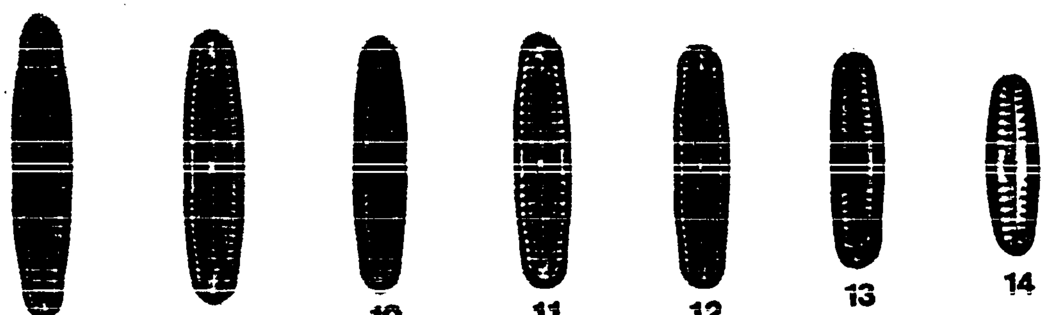
Valve structure and variability of
Pinnularia subcapitata Greg. var. *subcapitata*.
X1500. p. 65.

Fig. 1.	vl: 33 μm,	vb: 5 μm,	s/10 μm:	11.
Fig. 2.	vl: 29 μm,	vb: 5 μm,	s/10 μm:	13.
Fig. 3.	vl: 29 μm,	vb: 5 μm,	s/10 μm:	13.
Fig. 4.	vl: 29 μm,	vb: 4 μm,	s/10 μm:	12.
Fig. 5.	vl: 29 μm,	vb: 4 μm,	s/10 μm:	12.
Fig. 6.	vl: 28 μm,	vb: 4 μm,	s/10 μm:	12.
Fig. 7.	vl: 27 μm,	vb: 4 μm,	s/10 μm:	11.
Fig. 8.	vl: 26 μm,	vb: 5 μm,	s/10 μm:	13.
Fig. 9.	vl: 23 μm,	vb: 5 μm,	s/10 μm:	13.
Fig. 10.	vl: 22 μm,	vb: 4 μm,	s/10 μm:	11-12.
Fig. 11.	vl: 21 μm,	vb: 4 μm,	s/10 μm:	11.
Fig. 12.	vl: 21 μm,	vb: 4 μm,	s/10 μm:	11.
Fig. 13.	vl: 18 μm,	vb: 4 μm,	s/10 μm:	13.
Fig. 14.	vl: 16 μm,	vb: 4 μm,	s/10 μm:	13.

vl = valve length; vb = valve breadth; s/10 μm = number of striae per 10 μm interval



1 2 3 4 5 6 7



8 9 10 11 12 13 14

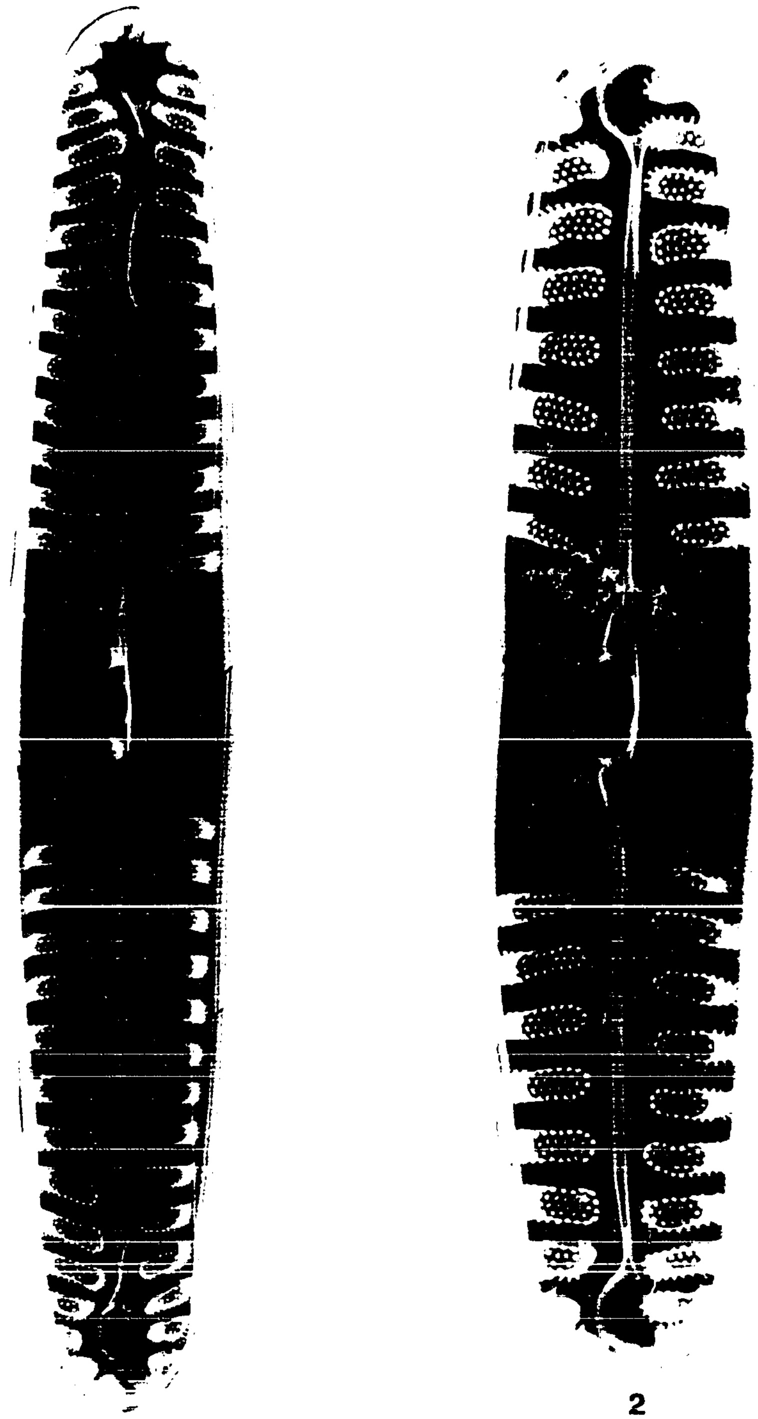
Plate XXIII

Carbon-metal replicas of
Pinnularia subcapitata Greg. var. *subcapitata*.

Fig. 1. *Pinnularia subcapitata* Greg. var. *subcapitata*.
Carbon-metal replica. X6000. TEM
evl: 31 µm, evb: 5 µm, es/10 µm: 10-11.

Fig. 2. *Pinnularia subcapitata* Greg. var. *subcapitata*.
Carbon-metal replica. X9000. TEM
evl: 20 µm, evb: 4 µm, es/10 µm: 12.

evl = estimated valve length; evb = estimated valve breadth;
es/10 µm = estimated number of striae per 10 µm interval



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Striae slightly radiate to radiate at the central area, slightly convergent to convergent at the apices, 11-15 in 10 μm (mean: 12 in 10 μm). Longitudinal bands absent. Raphe filiform, apical fissures "comma" shaped.

Two carbon-metal replicas of this taxon were examined (Plate XXIII). Both show the finely porous nature of the striae, lack of longitudinal banding, and the "comma" shaped apical raphe fissures.

Distribution: Found at 3 locations: Dead Man's Lake (Samples #1, 40, 42, 43, 44, 45, 47, and 48), the Freda Haffner Kettle Hole (Samples #25, 59, 60, and 61), and a pothole near Cayler Prairie (Sample #66).

Divergentes

Pinnularia abaujensis (Pant.) Ross var. abaujensis

(Plate XXIV)

Valves slightly to distinctly lanceolate, sometimes almost linear. Apices rostrate or subcapitate. Length: 35-82 μm, breadth: 7-12 μm. Axial area one-fourth to one-half of the valve breadth, expanding gradually toward the central area. Central area a bilateral fascia. Striae slightly radiate or radiate at the central area, convergent at the apices, 8-12 in 10 μm (mean: 10 in 10 μm). Longitudinal bands absent. Raphe filamentous, apical fissures "comma" to somewhat "scythe" shaped.

Distribution: Found in a large number of locations: Dead Man's Lake (Samples #1, 3, 42, 43, and 47), Carex mat near Dead Man's Lake (Sample #9), Jemmerson Slough (Sample #18), Freda Haffner Kettle Hole (Samples #25 and 60), and a variety of creeks and rivers (Samples #11, 87, 89, 90, 92, 93, 102, 119, 147, 148, 154, 159, and 161).

Pinnularia abaujensis var. subundulata (A. Mayer ex Hust.) Patr.

(Plate XXV)

Valves linear, margins very slightly undulate. Apices rostrate, occasionally subrostrate. Length: 32-94 μm,

Plate XXIV

Valve structure and variability of
Pinnularia abaujensis (Pant.) Ross var. *abaujensis*.
X1000. p. 74.

Fig. 1.	vl: 76 µm,	vb: 9 µm,	s/10 µm:	11.
Fig. 2.	vl: 71 µm,	vb: 11 µm,	s/10 µm:	11-12.
Fig. 3.	vl: 68 µm,	vb: 11 µm,	s/10 µm:	10.
Fig. 4.	vl: 64 µm,	vb: 9 µm,	s/10 µm:	10.
Fig. 5.	vl: 62 µm,	vb: 7 µm,	s/10 µm:	11.
Fig. 6.	vl: 57 µm,	vb: 10 µm,	s/10 µm:	10-11.
Fig. 7.	vl: 41 µm,	vb: 10 µm,	s/10 µm:	11.

vl = valve length; vb = valve breadth; s/10 µm = number of striae per 10 µm interval

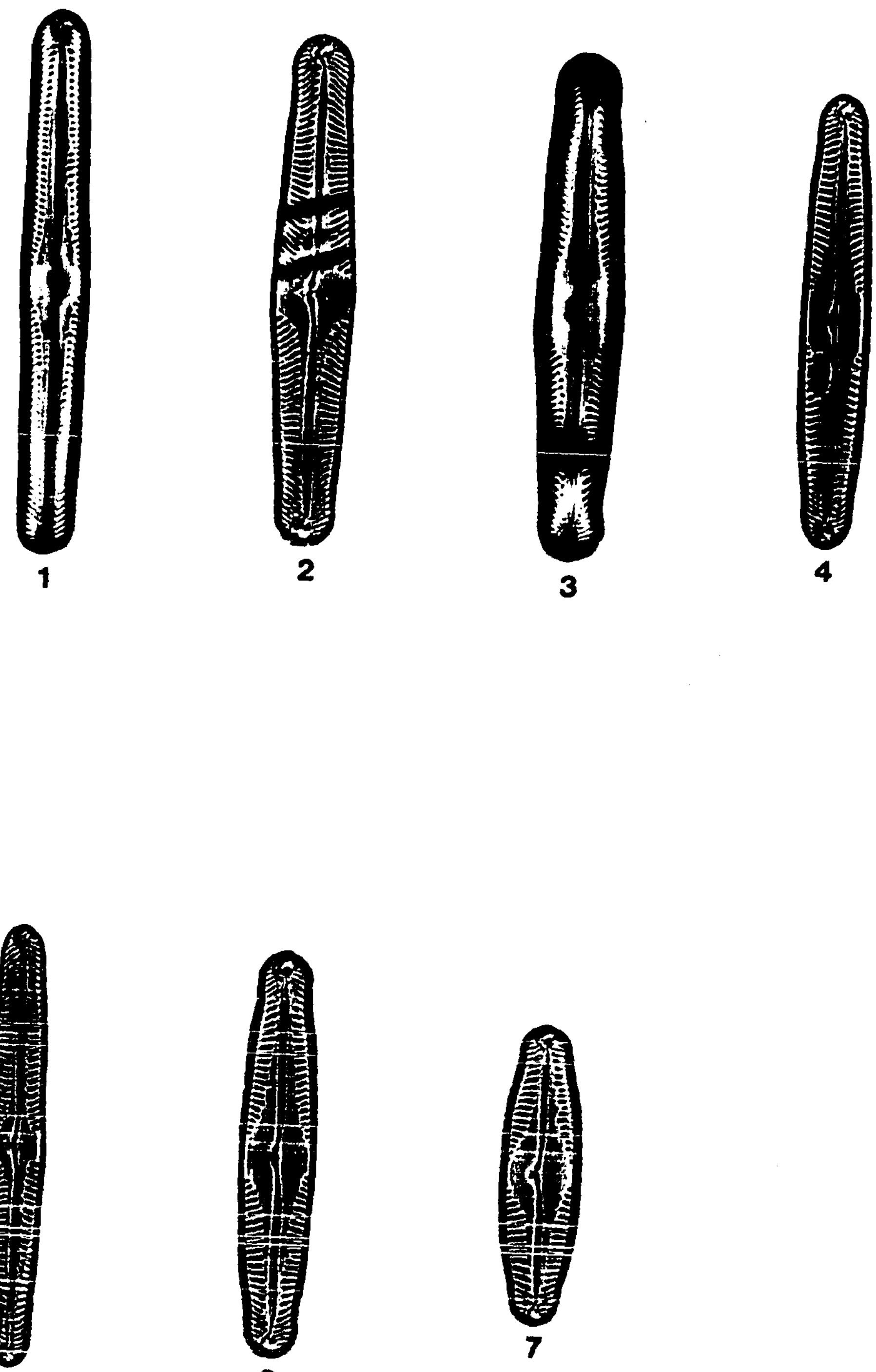

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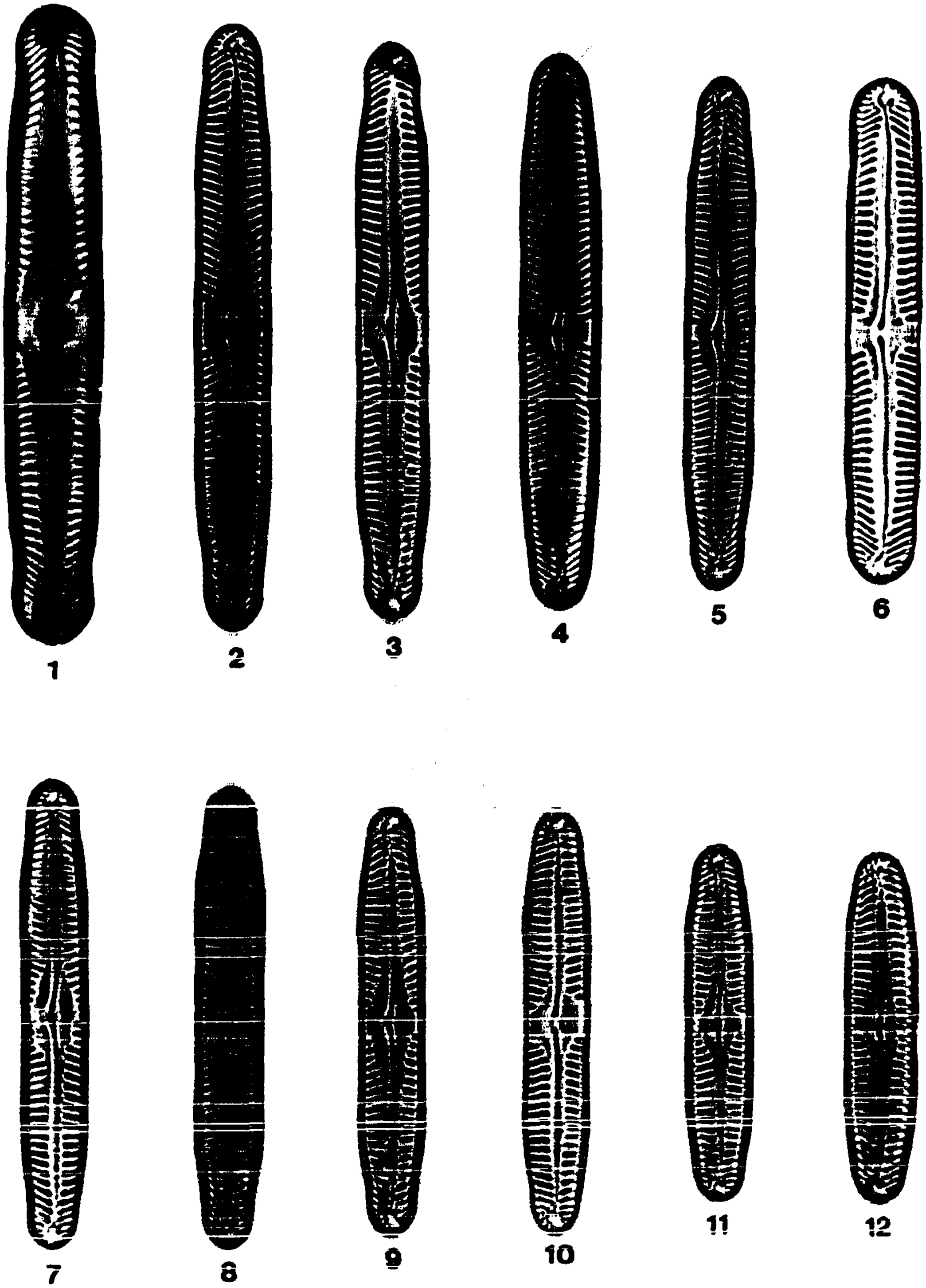
Plate XXV

Valve structure and variability of
Pinnularia _abaujensis_ var. _subundulata_ (A. Mayer _ex_ Hust.) Patr.
X1500. p. 74.

Fig. 1.	vl: 64 µm,	vb: 9 µm,	s/10 µm: 10.
Fig. 2.	vl: 60 µm,	vb: 7 µm,	s/10 µm: 11.
Fig. 3.	vl: 58 µm,	vb: 6 µm,	s/10 µm: 10.
Fig. 4.	vl: 55 µm,	vb: 7 µm,	s/10 µm: 11.
Fig. 5.	vl: 52 µm,	vb: 6 µm,	s/10 µm: 12.
Fig. 6.	vl: 51 µm,	vb: 7 µm,	s/10 µm: 11.
Fig. 7.	vl: 47 µm,	vb: 6 µm,	s/10 µm: 12.
Fig. 8.	vl: 46 µm,	vb: 6 µm,	s/10 µm: 11.
Fig. 9.	vl: 42 µm,	vb: 6 µm,	s/10 µm: 11.
Fig. 10.	vl: 40 µm,	vb: 6 µm,	s/10 µm: 12.
Fig. 11.	vl: 35 µm,	vb: 6 µm,	s/10 µm: 12.
Fig. 12.	vl: 34 µm,	vb: 6 µm,	s/10 µm: 11.

vl = valve length; vb = valve breadth; s/10 µm = number of striae per 10 µm interval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breadth: 6-14 μm. Axial area one-fourth to one-third of the valve breadth, expanding gradually as it approaches the central area. Central area frequently a bilateral fascia, but may be a unilateral fascia (Figs. 11 and 12), or an elliptical hyaline space (Fig. 7). Striae slightly radiate to radiate at the central area, slightly convergent to convergent at the apices, 9-14 in 10 μm (mean: 11 in 10 μm). Longitudinal bands absent. Raphe filamentous, at times slightly undulate (Figs. 1 and 6). Apical raphe fissures "comma" or somewhat "scythe" shaped (Figs. 2 and 5).

Distribution: Found at a large number of locations: Dead Man's Lake (Samples #1, 3, 10, 40, 42, 43, 44, and 48), an exposed lake bed (Sample #2), *Carex* mat near Dead Man's Lake (Sample #9), Jemmerson Slough (Sample #18), the Freda Haffner Kettle Hole (Samples #25, 60, and 62), a pond (Sample #64), a pothole near Cayler Prairie (Sample #66), and several rivers and streams (Samples #87, 90, 93, 124, 135, and 161).

Pinnularia intermedia (Lagerst.) Cl. var. *intermedia*

(Plate XXVI)

Valves linear with subrostrate apices. Length: 39-48 μm, breadth: 6-8 μm. Axial area one-fifth to one-fourth of the valve breadth. Central area a bilateral fascia. Striae slightly radiate to radiate at the central area, slightly convergent to convergent at the apices, 9-10 in 10 μm (mean: 9 in 10 μm). Longitudinal bands absent. Raphe narrow, slightly undulate to undulate. Apical raphe fissures "comma" shaped.

The valve interior of one specimen of this taxon was examined with the SEM (Plate XXVII, Figs. 1, 3, and 5). The tubular striae communicate with the valve interior via large foramina (Figs. 3 and 5). Within the foramina, the porous outer walls of the tubular striae are visible (Figs. 3 and 5). The inner raphe fissure is relatively straight and is uninterrupted at the central nodule (Figs. 1 and 3). At each polar nodule, the inner raphe fissure

Plate XXVI

Valve structure and variability of *Pinnularia intermedia* (Lagerst.) Cl. var. *intermedia*. X1500. p. 79.

Fig. 1. vl: 41 µm, vb: 7 µm, s/10 µm: 9.

Fig. 2. vl: 39 µm, vb: 7 µm, s/10 µm: 9-10.

vl = valve length; vb = valve breadth; s/10 µm = number of striae per 10 µm interval

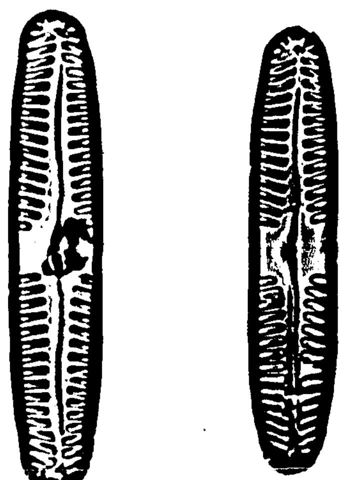

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Plate XXVII

Structure of the valve interior of *Pinnularia intermedia* (Lagerst.) Cl. var. *intermedia* and *Pinnularia obscura* Krasske var. *obscura*.

Fig. 1. *Pinnularia intermedia* (Lagerst.) Cl. var. *intermedia*.
Valve interior. X2040. SEM
vl: 38 µm, vb: 7 µm, s/10 µm: 10-11.

Fig. 2. *Pinnularia obscura* Krasske var. *obscura*.
Valve interior. X2440. SEM
vl: 29 µm, vb: 6 µm, s/10 µm: 11.

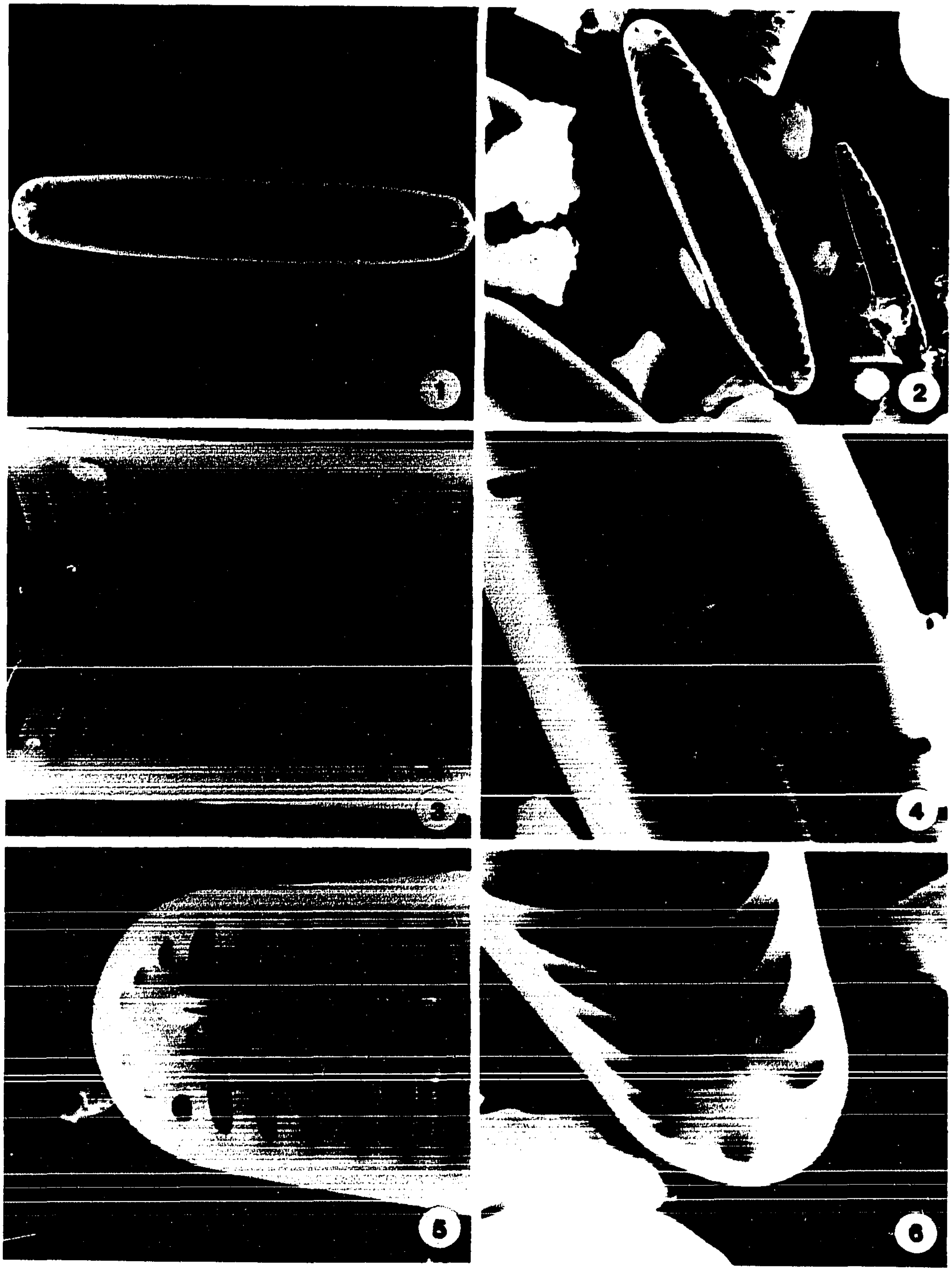
Fig. 3. *Pinnularia intermedia* (Lagerst.) Cl. var. *intermedia*.
Central area as viewed from the valve interior.
X8790. SEM

Fig. 4. *Pinnularia obscura* Krasske var. *obscura*.
Central area as viewed from the valve interior.
X11080. SEM

Fig. 5. *Pinnularia intermedia* (Lagerst.) Cl. var. *intermedia*.
Valve apex as viewed from the valve interior.
X8720. SEM

Fig. 6. *Pinnularia obscura* Krasske var. *obscura*.
Valve apex as viewed from the valve interior.
X11200. SEM

vl = valve length; vb = valve breadth; s/10 µm = number of striae per 10 µm interval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terminates in a small siliceous thickening (Figs. 1 and 5).

Distribution: Found at only 2 locations: the Freda Haffner Kettle Hole (Sample #25) and a pothole near Cayler Prairie (Sample #66). Only 6 specimens observed.

Pinnularia legumen (Ehr.) Ehr. var. legumen

(Plate XXVIII)

Valves linear with slightly undulate margins, undulation frequently absent in smaller specimens. Apices rostrate to subcapitate. Length: 39-104 µm, breadth: 9-18 µm. Axial area one-fifth to one-third of the valve breadth. Central area large, circular, sometimes nearly forming a fascia (Figs. 6, 7, 17, and 18), often ornamented with irregular spots (Figs. 3, 5, 6, and 19). Striae radiate at the central area, convergent at the apices, 9-13 in 10 µm (mean: 10 in 10 µm). Longitudinal bands absent or occurring only at the tips of the striae (Figs. 1 and 7). Raphe slightly undulate to undulate, apical fissures intermediate between "comma" and "bayonet" shapes.

Distribution: Found at a large number of locations: Jemmerson Slough (Sample #18), rivers and creeks (Samples #24, 26, 78, 80, 82, 83, 88, 89, 90, 93, 94, 105, 109, 118, 124, 135, 138, 140, 141, 146, 148, 150, 151, 152, 155, and 160), the Freda Haffner Kettle Hole (Sample #25), Big Wall Lake (Sample #32), Dead Man's Lake (Samples #40, 42, 43, 44, 45, 46, and 47), a pond near Big Wall Lake (Sample #52), and a pothole near Cayler Prairie (Sample #66).

Pinnularia microstauron var. brebissonii (Kütz.) Hust.

(Plate XXIX)

Valves linear, often slightly convex, apices cuneate. Length: 28-67 µm, breadth: 6-12 µm. Axial area one-sixth to one-fourth of the valve breadth. Central area a bilateral fascia (Figs. 2, 3, and 11), unilateral fascia (Figs. 5 and 9), elliptical (Fig. 1), or almost circular (Figs. 6, 8, 13, and 15). Striae slightly radiate to radiate at the central area, slightly convergent to convergent at the apices, 10-15 in 10 µm (mean: 13 in 10 µm). Longitudinal bands absent. Raphe filiform or a narrow filament, apical fissures "bayonet" or intermediate between "comma" and "bayonet" shapes.

Plate XXVIII

Valve structure and variability of
<u>Pinnularia</u> <u>legumen</u> (Ehr.) Ehr. var. <u>legumen</u>.
X1000. p. 84.

Fig. 1.	vl: 104 µm,	vb: 18 µm,	s/10 µm:	10.
Fig. 2.	vl: 92 µm,	vb: 17 µm,	s/10 µm:	9.
Fig. 3.	vl: 87 µm,	vb: 17 µm,	s/10 µm:	9.
Fig. 4.	vl: 78 µm,	vb: 15 µm,	s/10 µm:	9.
Fig. 5.	vl: 75 µm,	vb: 16 µm,	s/10 µm:	9.
Fig. 6.	vl: 75 µm,	vb: 15 µm,	s/10 µm:	9.
Fig. 7.	vl: 75 µm,	vb: 15 µm,	s/10 µm:	9-10.
Fig. 8.	vl: 72 µm,	vb: 15 µm,	s/10 µm:	9-10.
Fig. 9.	vl: 72 µm,	vb: 15 µm,	s/10 µm:	9-10.
Fig. 10.	vl: 68 µm,	vb: 15 µm,	s/10 µm:	10.

vl = valve length; vb = valve breadth; s/10 µm = number of striae per 10 µm interval

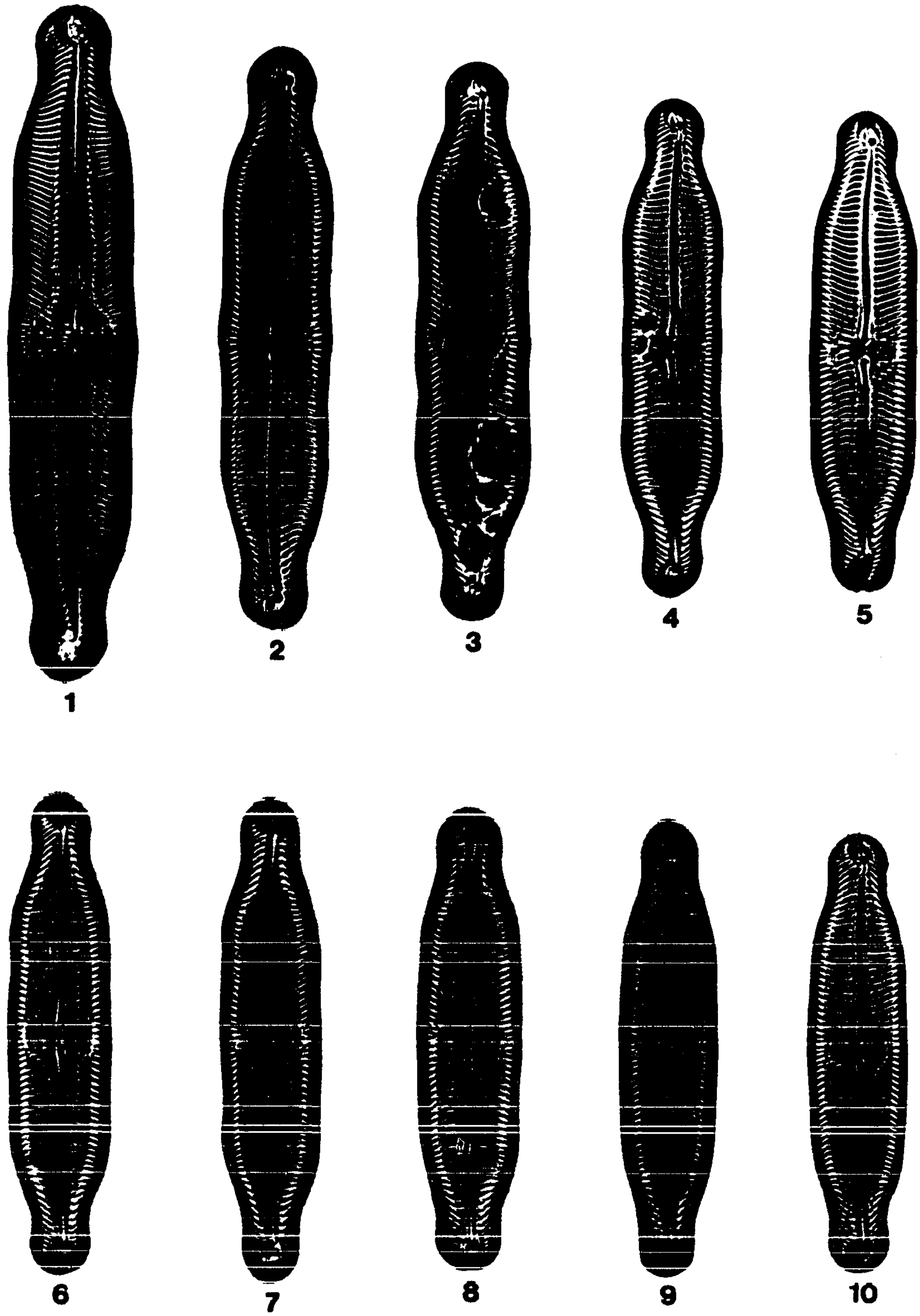

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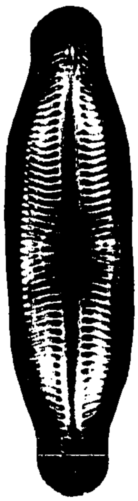
Plate XXVIII (continued)

Valve structure and variability of
Pinnularia legumen (Ehr.) Ehr. var. _legumen_.
X1000. p. 84.

Fig. 11.	vl: 65 μm,	vb: 17 μm,	s/10 μm:	9-10.
Fig. 12.	vl: 59 μm,	vb: 11 μm,	s/10 μm:	10-11.
Fig. 13.	vl: 56 μm,	vb: 14 μm,	s/10 μm:	9-10.
Fig. 14.	vl: 55 μm,	vb: 10 μm,	s/10 μm:	11-12.
Fig. 15.	vl: 51 μm,	vb: 10 μm,	s/10 μm:	12.
Fig. 16.	vl: 48 μm,	vb: 14 μm,	s/10 μm:	10-11.
Fig. 17.	vl: 46 μm,	vb: 10 μm,	s/10 μm:	11.
Fig. 18.	vl: 41 μm,	vb: 9 μm,	s/10 μm:	12.
Fig. 19.	vl: 41 μm,	vb: 9 μm,	s/10 μm:	12.
Fig. 20.	vl: 39 μm,	vb: 9 μm,	s/10 μm:	11.

vl = valve length; vb = valve breadth; s/10 μm = number of striae per 10 μm interval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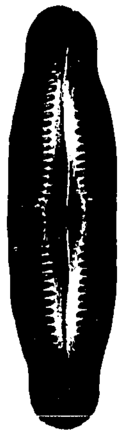
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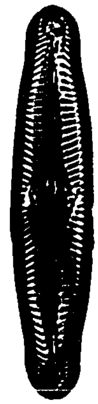
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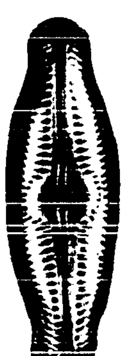
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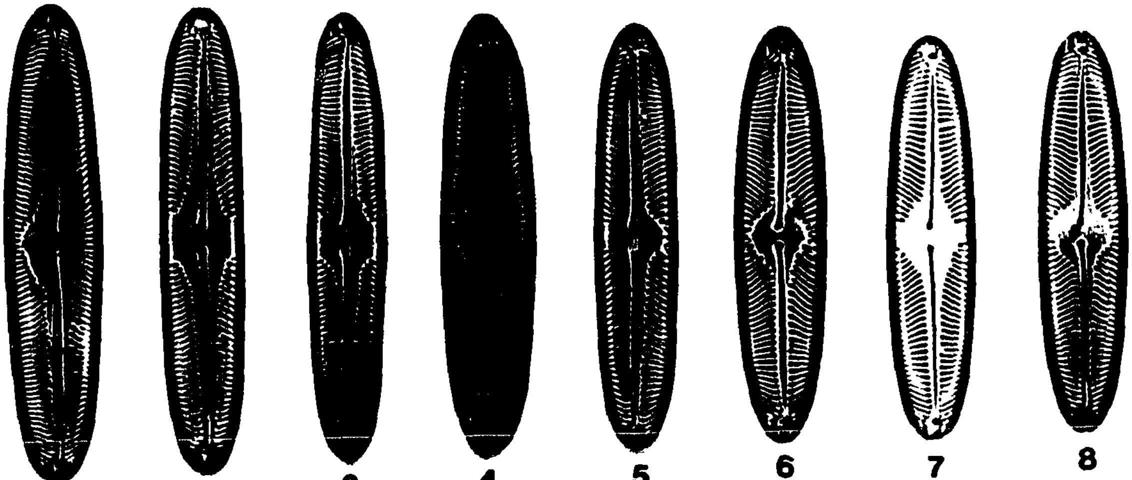
Plate XXIX

Valve structure and variability of
<u>Pinnularia</u> <u>microstauron</u> var. <u>brebissonii</u> (Kütz.) Hust.
X1000. p. 84.

Fig. 1.	vl: 64 µm,	vb: 12 µm,	s/10 µm:	14.
Fig. 2.	vl: 64 µm,	vb: 10 µm,	s/10 µm:	10-11.
Fig. 3.	vl: 61 µm,	vb: 9 µm,	s/10 µm:	13.
Fig. 4.	vl: 60 µm,	vb: 12 µm,	s/10 µm:	11.
Fig. 5.	vl: 58 µm,	vb: 10 µm,	s/10 µm:	11.
Fig. 6.	vl: 56 µm,	vb: 11 µm,	s/10 µm:	10-11.
Fig. 7.	vl: 55 µm,	vb: 11 µm,	s/10 µm:	14.
Fig. 8.	vl: 54 µm,	vb: 11 µm,	s/10 µm:	13.
Fig. 9.	vl: 51 µm,	vb: 11 µm,	s/10 µm:	11-12.
Fig. 10.	vl: 51 µm,	vb: 10 µm,	s/10 µm:	11.
Fig. 11.	vl: 47 µm,	vb: 10 µm,	s/10 µm:	12.
Fig. 12.	vl: 44 µm,	vb: 10 µm,	s/10 µm:	13.
Fig. 13.	vl: 41 µm,	vb: 10 µm,	s/10 µm:	13.
Fig. 14.	vl: 32 µm,	vb: 7 µm,	s/10 µm:	14.
Fig. 15.	vl: 29 µm,	vb: 8 µm,	s/10 µm:	13.
Fig. 16.	vl: 28 µm,	vb: 7 µm,	s/10 µm:	14.

vl = valve length; vb = valve breadth; s/10 µm = number of striae per 10 µm interval



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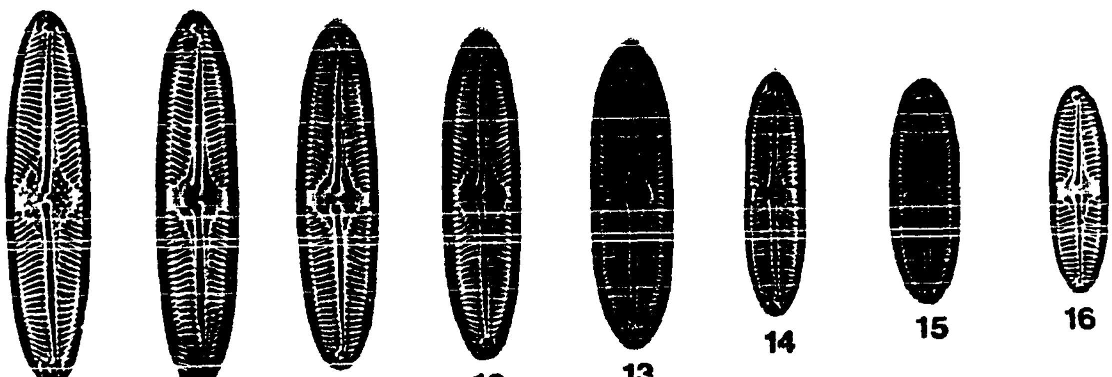

9 10 11 12 13 14 15 16

Distribution: Found at many locations: lakes and ponds (Samples #1, 14, 19, 32, 39, 42, 51, 52, 64, and 91), a drainage ditch (Sample #4), rivers and streams (Samples #6, 7, 11, 20, 24, 26, 30, 41, 50, 75, 84, 89, 90, 92, 98, 99, 102, 130, 131, 140, 142, 143, 146, 148, 149, 150, 152, 154, 155, 156, 157, 158, 159, and 160), Jemmerson Slough (Sample #18), Excelsior Fen (Sample #23), a seepage area (Samples #54 and 55), the Freda Haffner Kettle Hole (Sample #59), and a drainage pipe (Sample #71).

Pinnularia microstauron (Ehr.) Cl. var. microstauron

(Plate XXX)

Valves linear with subrostrate to bluntly rounded apices. Length: 24-88 μm, breadth: 7-18 μm. Axial area one-sixth to one-third of the valve breadth, broadening gradually as it approaches the central area. Central area typically a bilateral fascia, occasionally a unilateral fascia or elliptical. Striae slightly radiate to radiate at the central area, slightly convergent to convergent (occasionally parallel) at the apices, 9-14 in 10 μm (mean: 12 in 10 μm). Longitudinal bands absent. Raphe filiform or a narrow filament, apical fissures "bayonet" or intermediate between "comma" and "bayonet" shapes, sometimes appearing "comma" shaped.

Distribution: Found at many locations: a soil sample (Sample #5), rivers and streams (Samples #11, 20, 26, 41, 50, 76, 81, 88, 89, 90, 92, 93, 102, 112, 119, 120, 122, 124, 126, 130, 139, 140, 144, 146, 148, 151, and 161), lakes (Samples #16, 17, 19, 42, 43, 44, 48, 49, and 51), fens (Samples #21, 22, 23, 67, and 73), Jemmerson Slough (Sample #18), seepage areas (Samples #55 and 70), the Freda Haffner Kettle Hole (Sample #60), a pothole near Cayler Prairie (Sample #66), and a drainage pipe (Sample #71).

Pinnularia obscura Krasske var. obscura

(Plate XXXI)

Valves linear, apices subrostrate to rostrate. Length: 17-43 μm, breadth: 4-7 μm. Axial area one-fifth to one-third of the valve breadth. Central area a bilateral fascia. Striae parallel, slightly radiate, or radiate at the central area, strongly convergent at the apices,

Plate XXX

Valve structure and variability of
Pinnularia microstauron (Ehr.) Cl. var. *microstauron*.
X1000. p. 91.

Fig. 1.	vl: 87 µm,	vb: 15 µm,	s/10 µm:	11.
Fig. 2.	vl: 75 µm,	vb: 12 µm,	s/10 µm:	10.
Fig. 3.	vl: 70 µm,	vb: 13 µm,	s/10 µm:	11.
Fig. 4.	vl: 64 µm,	vb: 13 µm,	s/10 µm:	10.
Fig. 5.	vl: 54 µm,	vb: 12 µm,	s/10 µm:	11.
Fig. 6.	vl: 49 µm,	vb: 10 µm,	s/10 µm:	11-12.
Fig. 7.	vl: 48 µm,	vb: 10 µm,	s/10 µm:	12.
Fig. 8.	vl: 48 µm,	vb: 10 µm,	s/10 µm:	11.
Fig. 9.	vl: 44 µm,	vb: 7 µm,	s/10 µm:	12-13.
Fig. 10.	vl: 41 µm,	vb: 7 µm,	s/10 µm:	14.
Fig. 11.	vl: 40 µm,	vb: 10 µm,	s/10 µm:	12.
Fig. 12.	vl: 38 µm,	vb: 10 µm,	s/10 µm:	12.
Fig. 13.	vl: 34 µm,	vb: 9 µm,	s/10 µm:	13.
Fig. 14.	vl: 29 µm,	vb: 8 µm,	s/10 µm:	11.
Fig. 15.	vl: 25 µm,	vb: 9 µm,	s/10 µm:	13.
Fig. 16.	vl: 24 µm,	vb: 8 µm,	s/10 µm:	13.

vl = valve length; vb = valve breadth; s/10 µm = number of striae per 10 µm interval

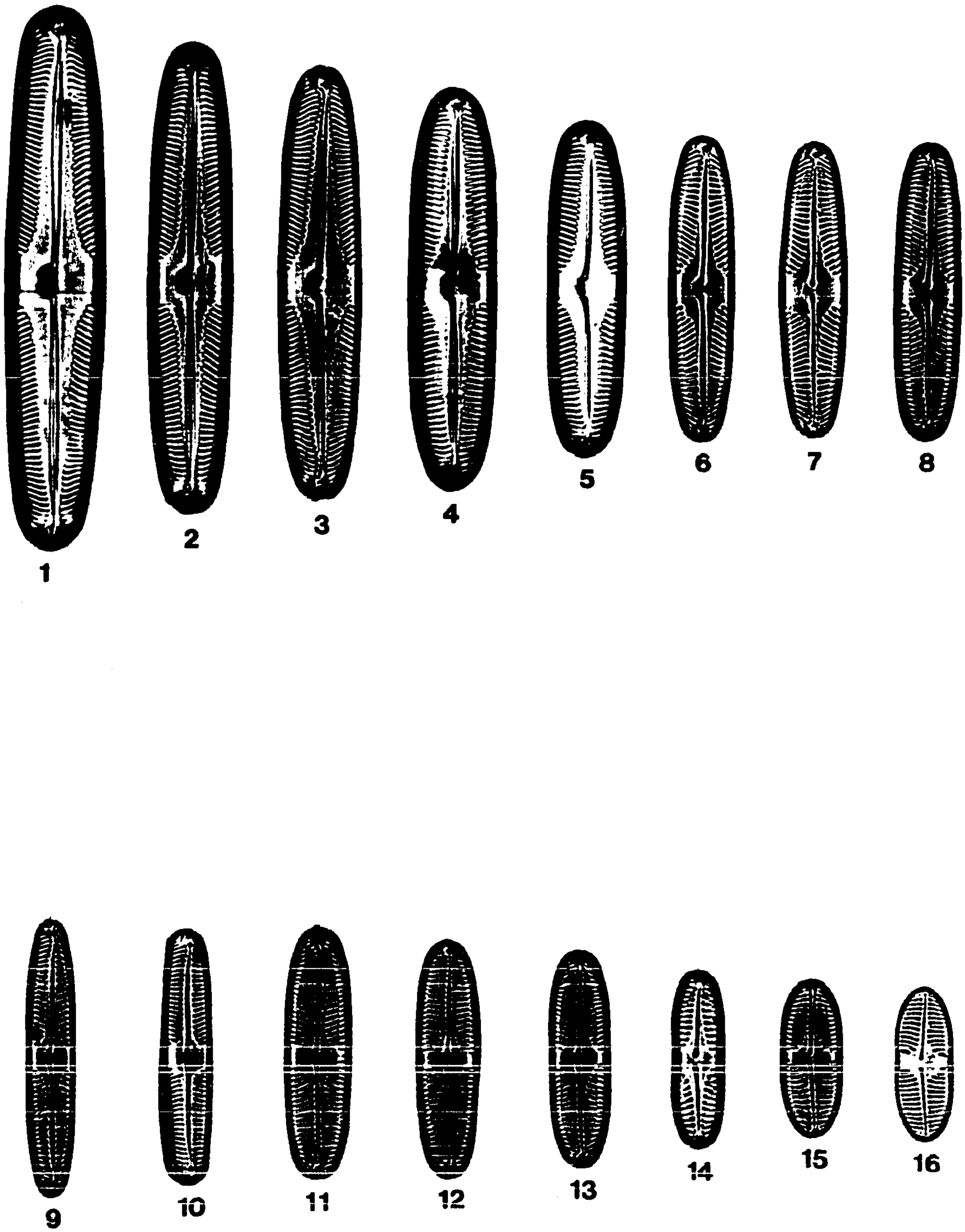
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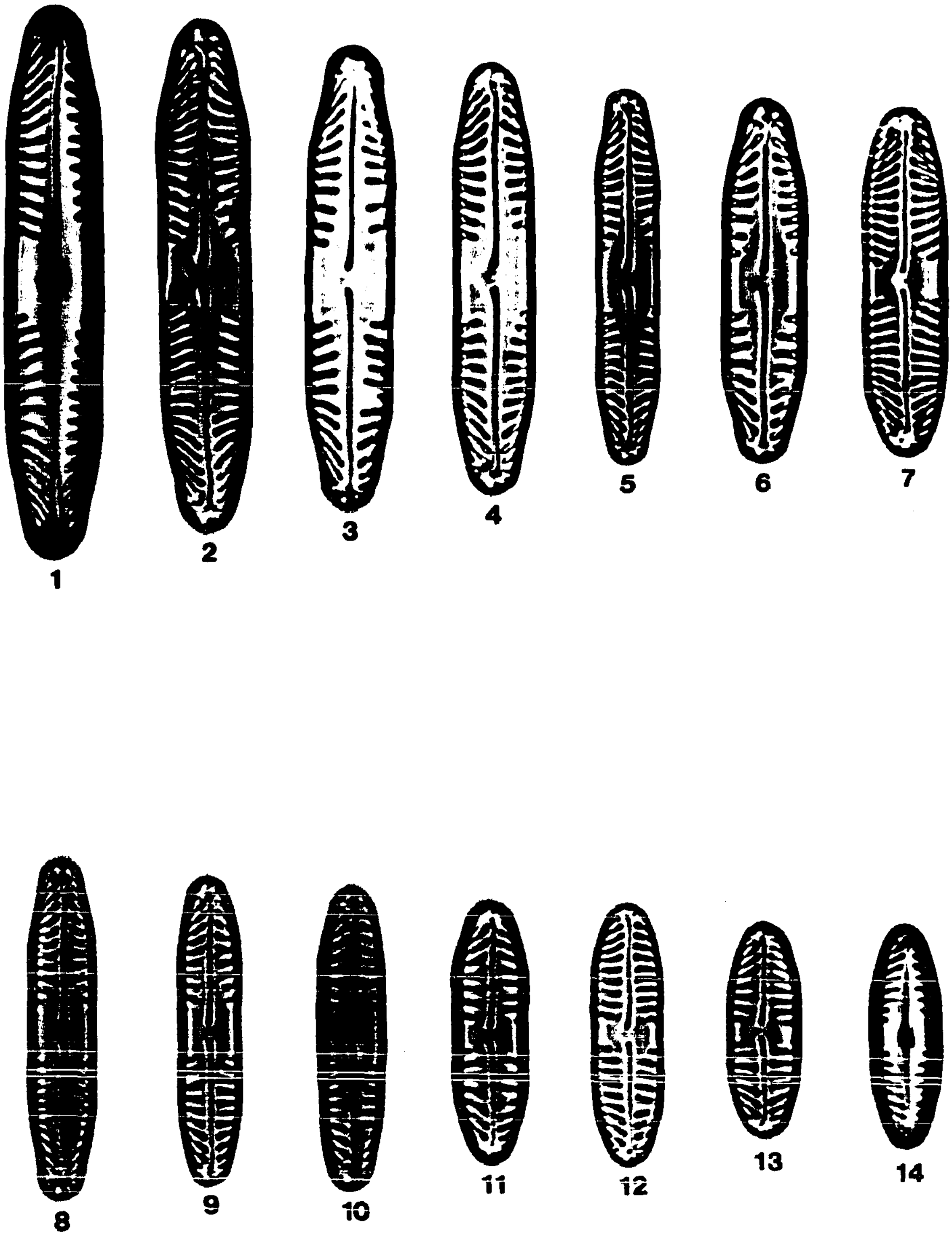
Plate XXXI

Valve structure and variability of
Pinnularia obscura Krasske var. *obscura*.
X2000. p. 91.

Fig. 1.	vl: 42 µm,	vb: 7 µm,	s/10 µm:	10.
Fig. 2.	vl: 40 µm,	vb: 6 µm,	s/10 µm:	10.
Fig. 3.	vl: 35 µm,	vb: 6 µm,	s/10 µm:	9-10.
Fig. 4.	vl: 33 µm,	vb: 6 µm,	s/10 µm:	11.
Fig. 5.	vl: 29 µm,	vb: 5 µm,	s/10 µm:	12-13.
Fig. 6.	vl: 28 µm,	vb: 6 µm,	s/10 µm:	10-11.
Fig. 7.	vl: 26 µm,	vb: 6 µm,	s/10 µm:	12.
Fig. 8.	vl: 26 µm,	vb: 5 µm,	s/10 µm:	13.
Fig. 9.	vl: 24 µm,	vb: 5 µm,	s/10 µm:	13.
Fig. 10.	vl: 23 µm,	vb: 4 µm,	s/10 µm:	12.
Fig. 11.	vl: 20 µm,	vb: 6 µm,	s/10 µm:	11.
Fig. 12.	vl: 20 µm,	vb: 5 µm,	s/10 µm:	13.
Fig. 13.	vl: 17 µm,	vb: 6 µm,	s/10 µm:	13.
Fig. 14.	vl: 17 µm,	vb: 5 µm,	s/10 µm:	13.

vl = valve length; vb = valve breadth; s/10 µm = number of striae per 10 µm interval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9-15 in 10 µm (mean: 12 in 10 µm). Longitudinal bands absent. Raphe filiform, apical fissures "comma" shaped (Fig. 4).

The valve interior of a specimen of this taxon was examined with the SEM (Plate XXVII, Figs. 2, 4, and 6). The foramina of the tubular striae are visible in Figures 2 and 6. No porous wall structure could be seen within the foramina. The inner raphe fissure is relatively straight and appears to be interrupted at the central nodule (Figs. 2 and 4). Each inner apical raphe fissure terminates in a small siliceous thickening (Figs. 2 and 6).

Distribution: Found at only 3 locations: Dead Man's Lake (Samples #1, 42, and 48), the Freda Haffner Kettle Hole (Samples #25, 59, and 60), and a pothole near Cayler Prairie (Sample #66).

Pinnularia stomatophora (Grun.) Cl. var. *stomatophora*

(Plate XXXII)

Valves linear, at times slightly undulate. Apices rostrate-cuneate or cuneate. Length: 41-105 µm, breadth: 6-12 µm. Axial area one-fifth to nearly one-half of the valve breadth. Central area frequently a bilateral fascia (Figs. 1, 6, and 10), but sometimes a unilateral fascia, or elliptical (Figs. 8 and 14), often ornamented with lunate markings (Figs. 3 and 4) or irregular spots (Figs. 6, 14, and 16). Striae slightly radiate to radiate at the central area, slightly convergent to convergent at the apices, 11-15 in 10 µm (mean: 13 in 10 µm). Longitudinal bands absent or appearing only near the tips of the striae. Raphe slightly undulate to undulate, apical fissures "bayonet" shaped.

Plate XXXIII, Figure 1, shows the foramina of the tubular striae, but the porous outer walls have been eroded away. The outer walls are intact in Figure 2, but are

Plate XXXII

Valve structure and variability of *Pinnularia stomatophora* (Grun.) Cl. var. *stomatophora*. X1000. p. 96.

Fig. 1.	vl: 100 µm,	vb: 11 µm,	s/10 µm: 12-13.
Fig. 2.	vl: 98 µm,	vb: 12 µm,	s/10 µm: 13.
Fig. 3.	vl: 88 µm,	vb: 11 µm,	s/10 µm: 12.
Fig. 4.	vl: 87 µm,	vb: 12 µm,	s/10 µm: 12.
Fig. 5.	vl: 82 µm,	vb: 10 µm,	s/10 µm: 12.
Fig. 6.	vl: 75 µm,	vb: 8 µm,	s/10 µm: 13.
Fig. 7.	vl: 74 µm,	vb: 9 µm,	s/10 µm: 13.
Fig. 8.	vl: 72 µm,	vb: 9 µm,	s/10 µm: 12-13.
Fig. 9.	vl: 67 µm,	vb: 9 µm,	s/10 µm: 13.
Fig. 10.	vl: 60 µm,	vb: 9 µm,	s/10 µm: 12.
Fig. 11.	vl: 57 µm,	vb: 9 µm,	s/10 µm: 12.
Fig. 12.	vl: 55 µm,	vb: 8 µm,	s/10 µm: 11.
Fig. 13.	vl: 54 µm,	vb: 9 µm,	s/10 µm: 12.
Fig. 14.	vl: 52 µm,	vb: 10 µm,	s/10 µm: 13.
Fig. 15.	vl: 50 µm,	vb: 7 µm,	s/10 µm: 14.
Fig. 16.	vl: 41 µm,	vb: 8 µm,	s/10 µm: 13.

vl = valve length; vb = valve breadth; s/10 µm = number of striae per 10 µm interval

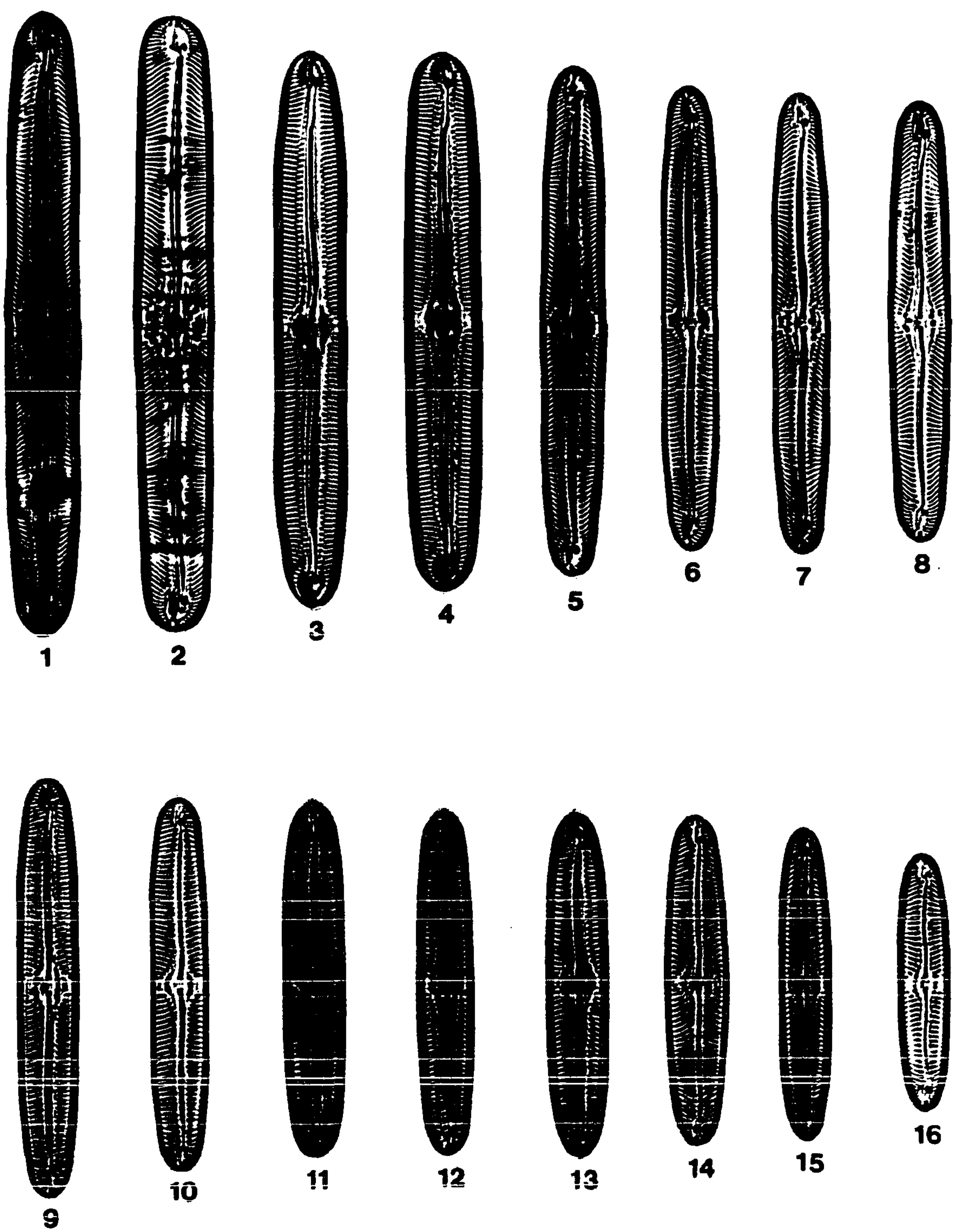
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Plate XXXIII

Carbon-metal replicas of
<u>Pinnularia</u> <u>stomatophora</u> (Grun.) Cl. var. <u>stomatophora</u>.

Fig. 1. <u>Pinnularia</u> <u>stomatophora</u> (Grun.) Cl. var. <u>stomatophora</u>.

Carbon-metal replica. X3000. TEM

vl: 58 μm, vb: 9 μm, s/10 μm: 13.

Fig. 2. <u>Pinnularia</u> <u>stomatophora</u> (Grun.) Cl. var. <u>stomatophora</u>.

Carbon-metal replica. X2020. TEM

evl: 65 μm, evb: 9 μm, es/10 μm: 14.

vl = valve length; vb = valve breadth; s/10 μm = number of striae per 10 μm interval

evl = estimated valve length; evb = estimated valve breadth; es/10 μm = estimated number of striae per 10 μm interval

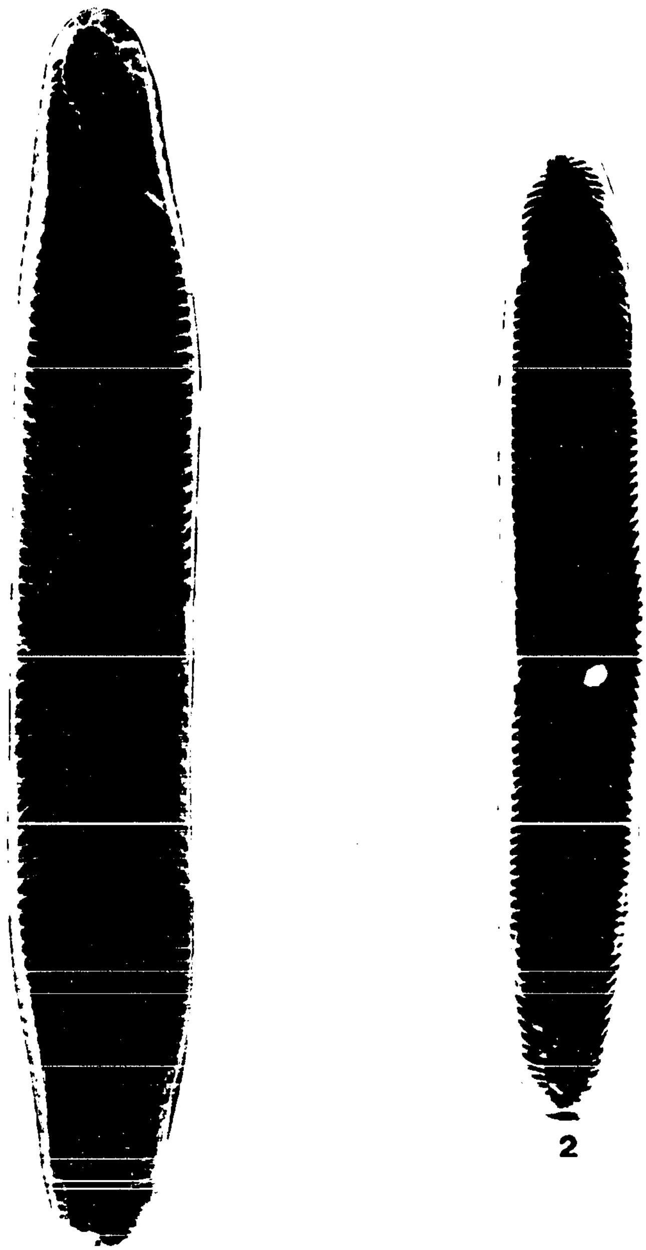

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Plate XXXIV

Structure of the valve exterior and valve interior of *Pinnularia stomatophora* (Grun.) Cl. var. *stomatophora*.

Fig. 1. *Pinnularia stomatophora* (Grun.) Cl. var. *stomatophora*.

Valve exterior. X740. SEM

vl: 88 μm, vb: 12 μm, s/10 μm: 12.

Fig. 2. *Pinnularia stomatophora* (Grun.) Cl. var. *stomatophora*.

Valve interior. X1240. SEM

vl: 53 μm, vb: 7-8 μm, s/10 μm: 12.

Fig. 3. *Pinnularia stomatophora* (Grun.) Cl. var. *stomatophora*.

Central area as viewed from the valve exterior.

X6600. SEM

Fig. 4. *Pinnularia stomatophora* (Grun.) Cl. var. *stomatophora*.

Central area as viewed from the valve interior.

X7260. SEM

Fig. 5. *Pinnularia stomatophora* (Grun.) Cl. var. *stomatophora*.

Valve apex as viewed from the valve exterior.

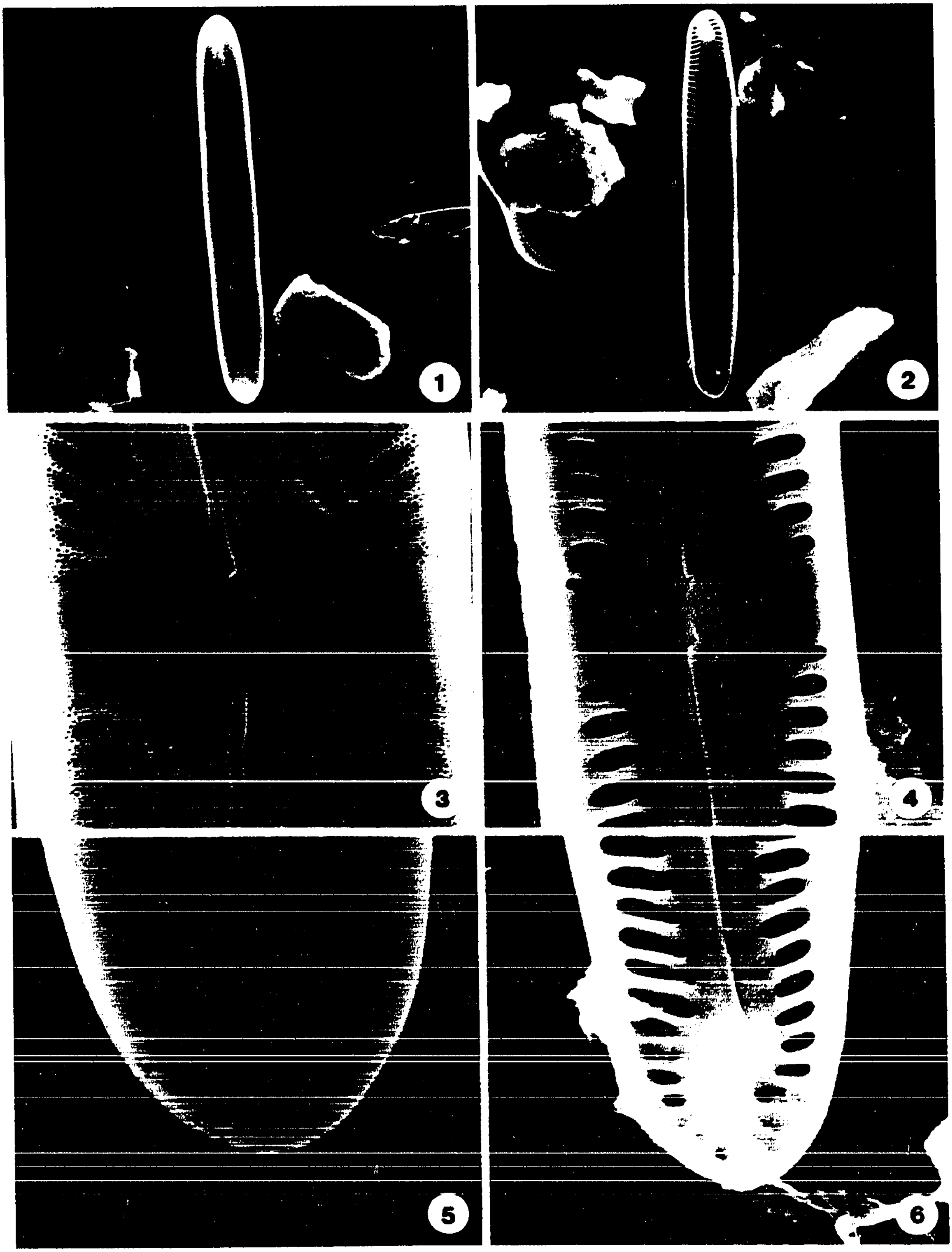
X6760. SEM

Fig. 6. *Pinnularia stomatophora* (Grun.) Cl. var. *stomatophora*.

Valve apex as viewed from the valve interior.

X7280. SEM

vl = valve length; vb = valve breadth; s/10 μm = number of striae per 10 μm interval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obscure. Neither figure provides a clear image of the apical raphe fissures.

Plate XXXIV depicts the outer (Figs. 1, 3, and 5) and inner (Figs. 2, 4, and 6) valve features of this taxon as they appear using SEM. The porous outer walls of the tubular striae are clearly visible in Figures 3 and 5 and can also be detected within the foramina in Figures 4 and 6. The slightly undulate outer raphe fissure (Fig. 1) terminates at the central nodule in two pores (Fig. 3), and at each apex in a hook-like fissure (Fig. 5). The inner raphe fissure is relatively straight and is interrupted at the central nodule (Figs. 2 and 4). At the valve apices, the inner raphe fissure deviates slightly to one side before ending in a small siliceous thickening (Figs. 2 and 6). The structure of the lunate markings bordering the central nodule (Figs. 1 and 3) is unclear.

Distribution: Found at many locations: Dead Man's Lake (Samples #1, 3, 10, 40, 42, 43, 44, 45, 46, 47, and 48), an exposed lake bed (Sample #2), a *Carex* mat near Dead Man's Lake (Sample #9), fens (Samples #15, 21, 22, 23, 67, 68, and 73), Jemmerson Slough (Sample #18), the Freda Haffner Kettle Hole (Samples #25, 58, 59, 61, and 62), creeks and rivers (Samples #41, 90, 117, 127, and 156), ponds and lakes (Samples #52, 63, 64, and 74), and seepage areas (Samples #55 and 70).

Pinnularia species #2

(Plate XXXV)

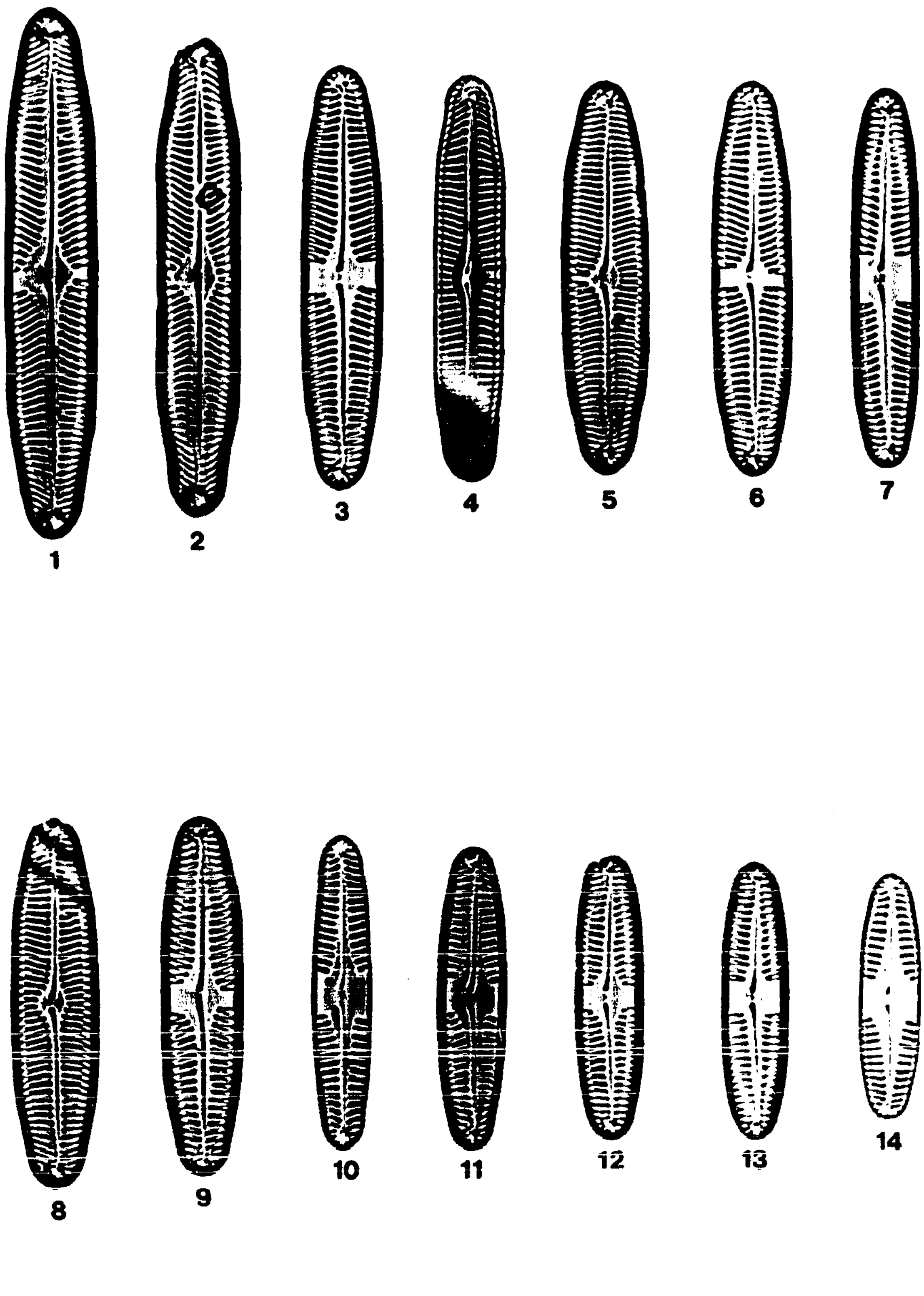
Valves linear, apices subrostrate to rostrate. Length: 26-56 μm, breadth: 6-9 μm. Axial area one-eighth to

Plate XXXV

Valve structure and variability of
<u>Pinnularia</u> species #2.
X1500. p. 103.

Fig. 1.	vl: 56 µm,	vb: 9 µm,	s/10 µm: 10-11.
Fig. 2.	vl: 51 µm,	vb: 8 µm,	s/10 µm: 11-12.
Fig. 3.	vl: 45 µm,	vb: 8 µm,	s/10 µm: 12.
Fig. 4.	vl: 42 µm,	vb: 6 µm,	s/10 µm: 12.
Fig. 5.	vl: 41 µm,	vb: 9 µm,	s/10 µm: 13.
Fig. 6.	vl: 41 µm,	vb: 8 µm,	s/10 µm: 13.
Fig. 7.	vl: 40 µm,	vb: 6 µm,	s/10 µm: 12.
Fig. 8.	vl: 39 µm,	vb: 9 µm,	s/10 µm: 12-13.
Fig. 9.	vl: 38 µm,	vb: 8 µm,	s/10 µm: 12.
Fig. 10.	vl: 33 µm,	vb: 6 µm,	s/10 µm: 12.
Fig. 11.	vl: 32 µm,	vb: 6 µm,	s/10 µm: 14.
Fig. 12.	vl: 30 µm,	vb: 6 µm,	s/10 µm: 13.
Fig. 13.	vl: 29 µm,	vb: 6 µm,	s/10 µm: 12-13.
Fig. 14.	vl: 26 µm,	vb: 6 µm,	s/10 µm: 13.

vl = valve length; vb = valve breadth; s/10 µm = number of striae per 10 µm interval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one-third of the valve breadth. Central area frequently a bilateral fascia (Figs. 3 and 7), occasionally a unilateral fascia or elliptical (Figs. 4 and 8). Striae slightly radiate to radiate at the central area, slightly convergent to convergent at the apices, 10-14 in 10 µm (mean: 12 in 10 µm). Longitudinal bands absent or occurring only at the tips of the striae bordering the central area. Raphe filiform or a narrow filament, apical fissures "comma" shaped.

Distribution: Found at only 3 locations: Dead Man's Lake (Samples #1, 3, 40, 42, 43, 44, 45, and 47), Carex mat near Dead Man's Lake (Sample #9), and the Freda Haffner Kettle Hole (Sample #60).

Pinnularia species #3

(Plate XXXVI)

Valves linear, apices typically subcapitate, but varying from rostrate to capitate. Length: 32-87 µm, breadth: 9-13 µm. Axial area one-fifth to one-third of the valve breadth, broadening gradually toward the central area. Central area typically a bilateral fascia, but may be elliptical. Striae slightly radiate to radiate at the central area, convergent to strongly convergent at the apices, 8-13 in 10 µm (mean: 10 in 10 µm). Longitudinal bands absent. Raphe filiform or filamentous, apical fissures intermediate between "comma" and "bayonet" shaped, sometimes "comma" shaped.

Distribution: Found at many locations: various rivers and creeks (Samples #11, 87, 89, 90, 92, 93, 104, 115, 116, 118, 119, 120, 122, 124, 142, 143, 146, 149, 150, 151, 152, 154, 158, 160, and 161) and West Lake Okoboji (Sample #19).

Maiores

Pinnularia maior (Kütz.) Rabh. var. maior

(Plate XXXVII)

Valves linear, frequently somewhat inflated at the central area. Apices bluntly rounded, sometimes slightly cuneate. Length: 141-276 µm, breadth: 22-34 µm. Axial area one-fourth to one-third of the valve breadth. Central area small, asymmetrically rounded. Striae slightly

Plate XXXVI

Valve structure and variability of
Pinnularia species #3.
X1000. p. 106.

Fig. 1.	vl: 72 μm,	vb: 13 μm,	s/10 μm: 9.
Fig. 2.	vl: 68 μm,	vb: 12 μm,	s/10 μm: 9-10.
Fig. 3.	vl: 64 μm,	vb: 12 μm,	s/10 μm: 9-10.
Fig. 4.	vl: 61 μm,	vb: 12 μm,	s/10 μm: 9-10.
Fig. 5.	vl: 59 μm,	vb: 11 μm,	s/10 μm: 10.
Fig. 6.	vl: 56 μm,	vb: 12 μm,	s/10 μm: 10-11.
Fig. 7.	vl: 53 μm,	vb: 12 μm,	s/10 μm: 10.
Fig. 8.	vl: 51 μm,	vb: 12 μm,	s/10 μm: 10.
Fig. 9.	vl: 44 μm,	vb: 11 μm,	s/10 μm: 11-12.
Fig. 10.	vl: 38 μm,	vb: 10 μm,	s/10 μm: 11.

vl = valve length; vb = valve breadth; s/10 μm = number of striae per 10 μm interval

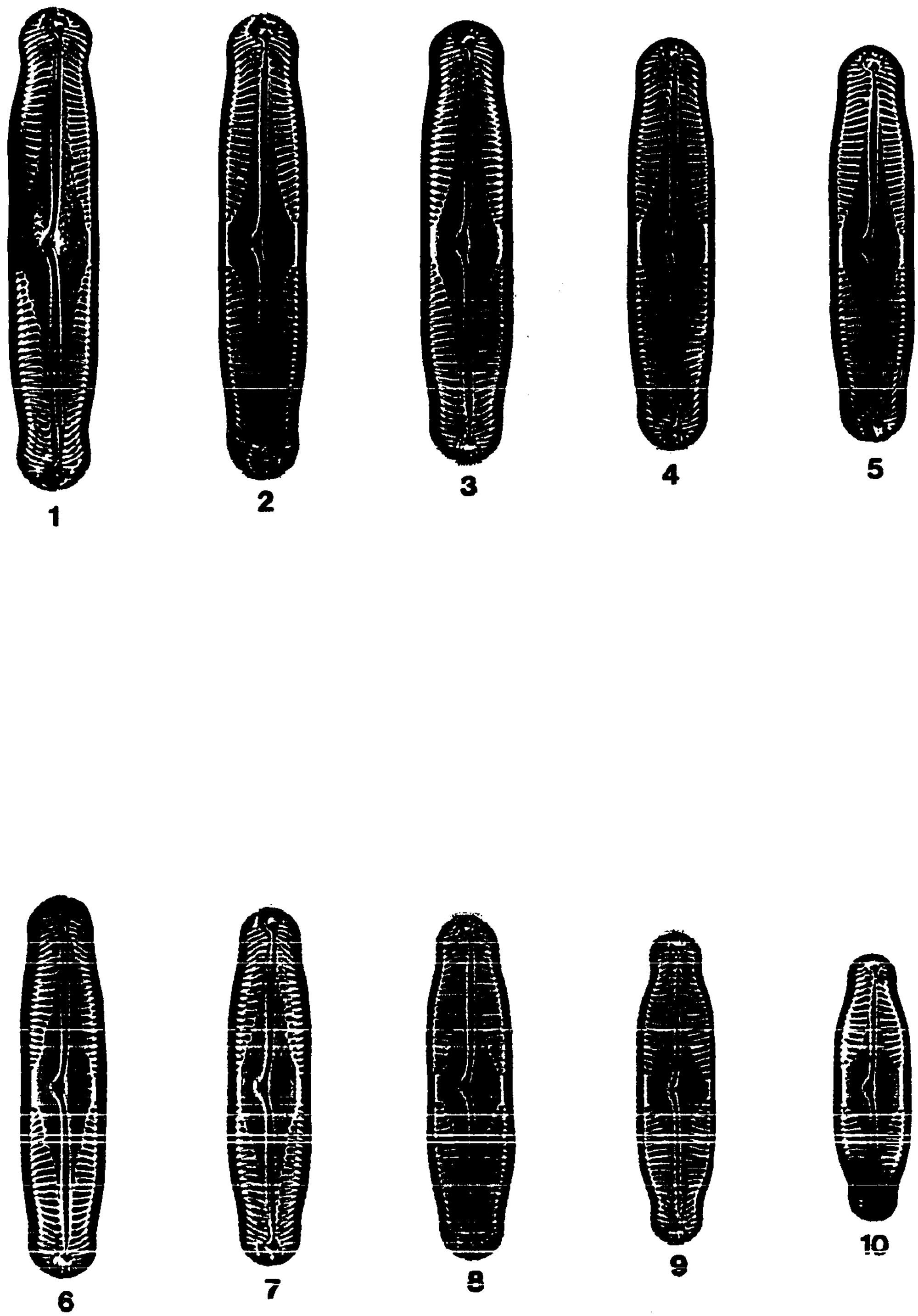
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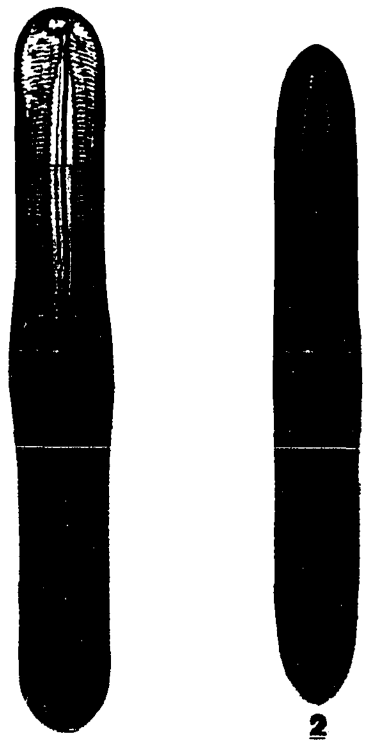
Plate XXXVII

Valve structure and variability of
Pinnularia _maior_ (Kütz.) Rabh. var. _maior_.
X500. p. 106.

Fig. 1. vl: 193 µm, vb: 26 µm, s/10 µm: 7-8.

Fig. 2. vl: 175 µm, vb: 22 µm, s/10 µm: 6-7.

vl = valve length; vb = valve breadth; s/10 µm = number of striae per 10 µm interval



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radiate to radiate at the central area, parallel to convergent at the apices, 6-8 in 10 μm (mean: 7 in 10 μm). Breadth of the longitudinal bands one-fifth to two-thirds of the striae length. Raphe a broad filament, occasionally appearing very slightly complex. Apical raphe fissures "question mark" shaped.

Distribution: Found at 4 locations: Carex mat near Dead Man's Lake (Sample #9), Silver Lake Fen (Sample #15), West Lake Okoboji (Sample #19), and Dead Man's Lake (Sample #40). Only 9 specimens observed.

Pinnularia maior var. pulchella Boyer

(Plate XXXVIII)

Valves linear, inflated at the central area. Apices bluntly rounded, sometimes slightly inflated. Length: 170-232 μm, breadth: 31-38 μm. Axial area one-fourth to one-third of the valve breadth, often faintly granular (Figs. 1 and 2). Central area small, asymmetrically rounded. Striae radiate at the central area, slightly convergent to convergent at the apices, 7-8 in 10 μm (mean: 7 in 10 μm). Longitudinal bands broad, evident only near the striae tips (Figs. 3 and 4). Raphe filamentous, slightly undulate. Apical raphe fissures "question mark" shaped (Figs. 1 and 2).

Distribution: Found only at Dead Man's Lake (Samples #2 and 45). Only 6 specimens observed.

Pinnularia maior var. transversa (A.S.) Cl.

(Plate XXXIX)

Valves linear, frequently slightly inflated at the central area. Apices rounded, slightly cuneate, sometimes slightly inflated. Length: 134-240 μm, breadth: 16-23 μm. Axial area one-fifth to one-third of the valve breadth. Central area small, asymmetrically rounded, sometimes barely wider than the axial area. Striae slightly radiate to radiate at the central area, slightly convergent to convergent at the apices, 8-9 in 10 μm (mean: 9 in 10 μm). Longitudinal bands one-fifth to one-third of the striae length. Raphe a broad filament, apical fissures "question mark" shaped.

Plate XXXVIII

Valve structure and variability of
Pinnularia maior var. *pulchella* Boyer.
X500. p. 111.

Fig. 1.	vl: 232 μm,	vb: 38 μm,	s/10 μm:	7.
Fig. 2.	vl: 202 μm,	vb: 34 μm,	s/10 μm:	7.
Fig. 3.	vl: 180 μm,	vb: 32 μm,	s/10 μm:	7-8.
Fig. 4.	vl: 170 μm,	vb: 32 μm,	s/10 μm:	7.
Fig. 5.	vl: 170 μm,	vb: 31 μm,	s/10 μm:	7.

vl = valve length; vb = valve breadth; s/10 μm = number of striae per 10 μm interval

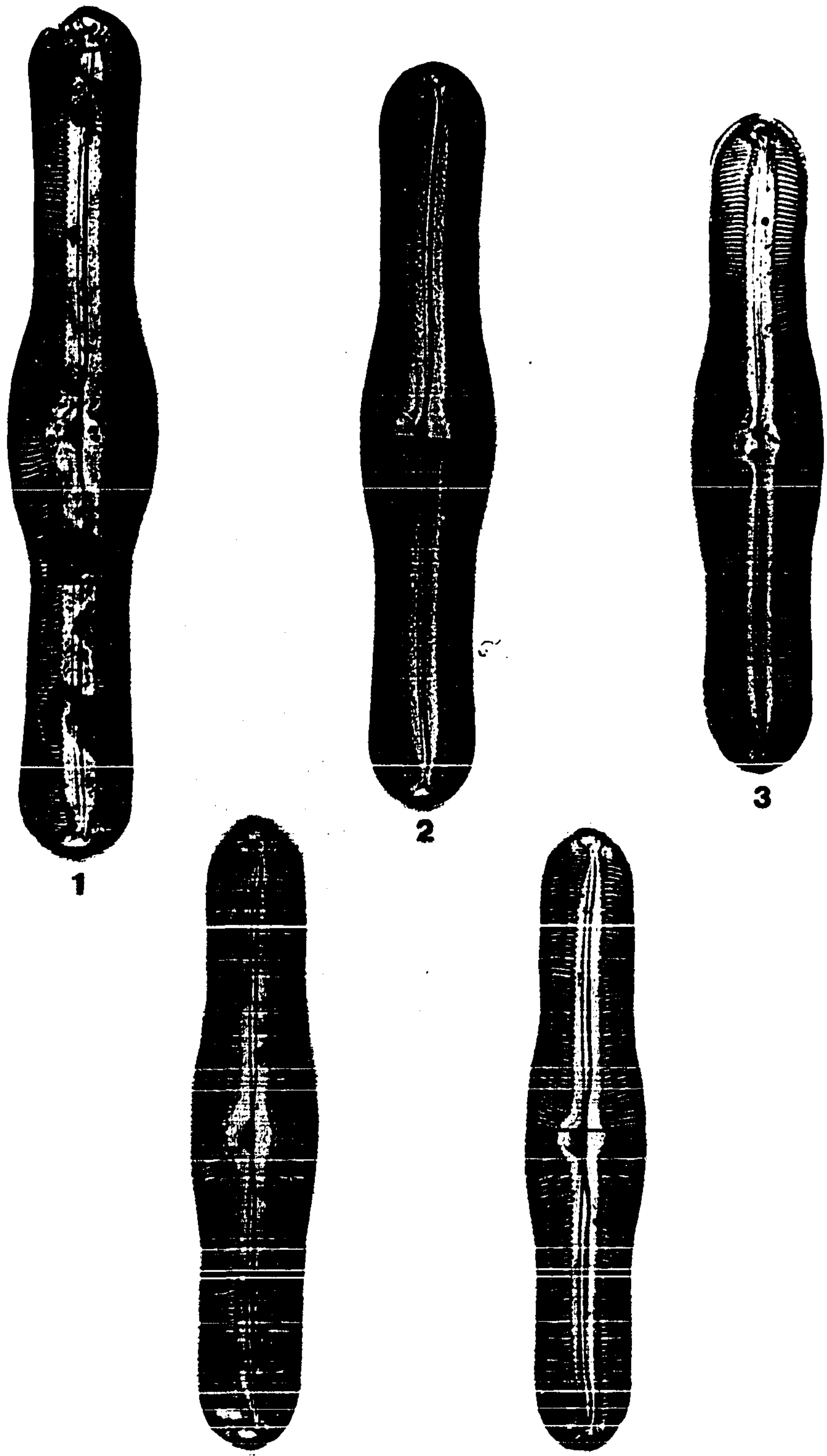

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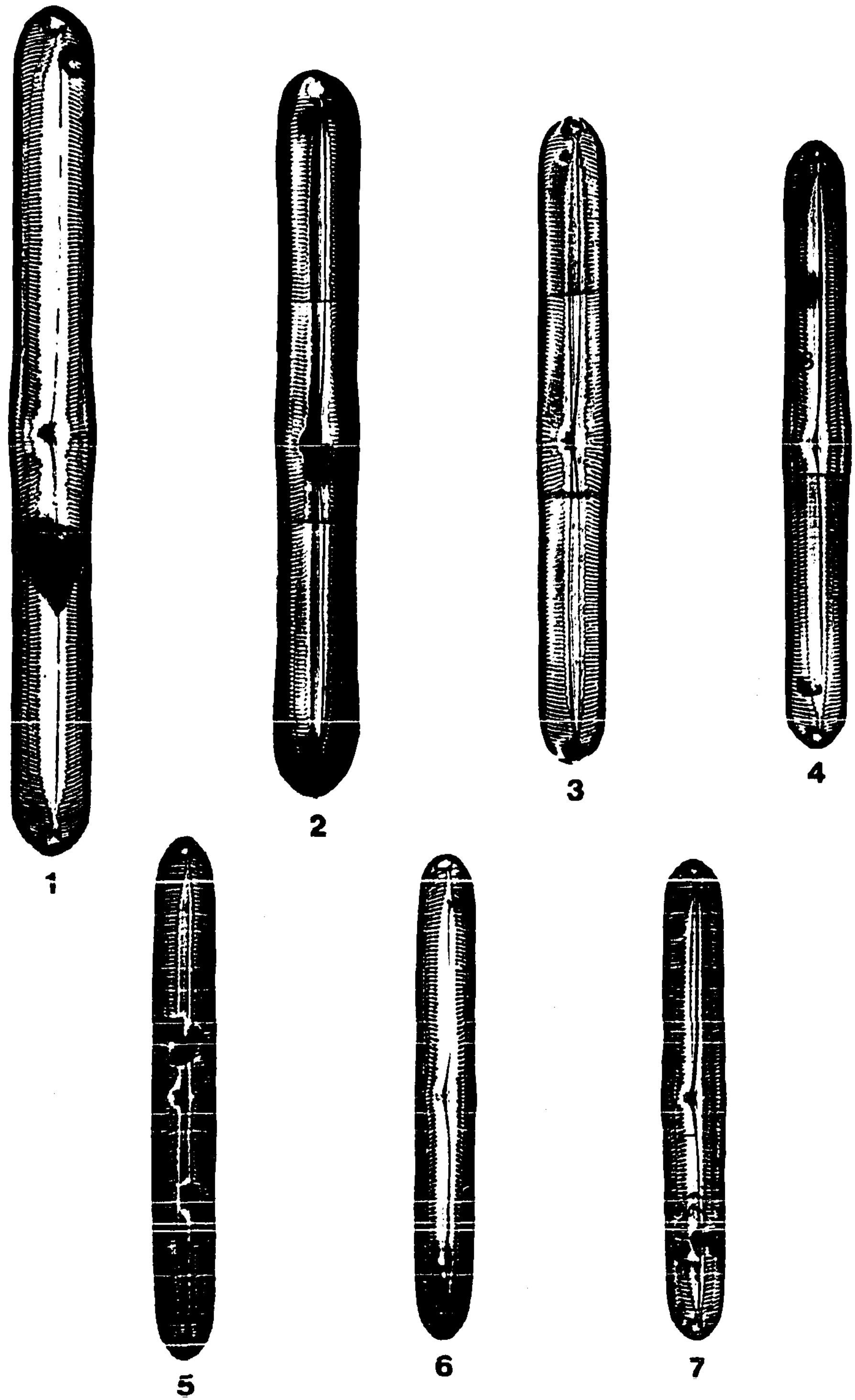
Plate XXXIX

Valve structure and variability of
Pinnularia maior var. *transversa* (A.S.) Cl.
X500. p. 111.

Fig. 1.	vl: 236 µm,	vb: 23 µm,	s/10 µm:	9.
Fig. 2.	vl: 200 µm,	vb: 22 µm,	s/10 µm:	9.
Fig. 3.	vl: 176 µm,	vb: 18 µm,	s/10 µm:	9.
Fig. 4.	vl: 167 µm,	vb: 18 µm,	s/10 µm:	8-9.
Fig. 5.	vl: 146 µm,	vb: 18 µm,	s/10 µm:	9.
Fig. 6.	vl: 134 µm,	vb: 16 µm,	s/10 µm:	8.
Fig. 7.	vl: 134 µm,	vb: 18 µm,	s/10 µm:	9.

vl = valve length; vb = valve breadth; s/10 µm = number of striae per 10 µm interval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Distribution: Found at only 2 locations: an exposed lake bed (Sample #2) and Dead Man's Lake (Samples #42, 44, and 45). Only 17 specimens observed.

Complexae

Pinnularia ruttneri Hust. var. ruttneri

(Plate XL)

Valves linear, sometimes very slightly inflated at the central area. Apices bluntly rounded or rounded-cuneate. Length: 114-230 µm, breadth: 14-29 µm. Axial area one-fourth to one-third of the valve breadth. Central area small, asymmetrically rounded (Figs. 1, 6, and 9), or not clearly differentiated from the axial area (Figs. 8, 13, and 14). Striae slightly radiate to radiate at the central area, convergent, slightly convergent, or parallel at the apices, 6-9 in 10 µm (mean: 7 in 10 µm). Breadth of the longitudinal bands one-sixth to one-third of the length of the striae. Raphe moderately to highly complex, apical fissures "question mark" shaped.

Three specimens of this taxon were examined with the SEM (Plate XLI, Figs. 2, 4, and 6). In Figure 2, a view of the valve exterior, the asymmetrically rounded central area is visible, but the complex nature of the outer raphe fissure is not. In Figures 4 and 6, views of the valve interior, the inner raphe fissure is relatively straight and is uninterrupted at the central nodule. At each polar nodule, the inner raphe fissure terminates in a small siliceous thickening. The foramina occur near the valve margins and are most conspicuous in views of the valve interior (Figs. 4 and 6), but are also visible from the valve exterior (Fig. 2).

Plate XL

Valve structure and variability of
Pinnularia ruttneri Hust. var. ruttneri.
X500. p. 116.

Fig. 1.	vl: 230 µm,	vb: 26 µm,	s/10 µm: 6-7.
Fig. 2.	vl: 221 µm,	vb: 25 µm,	s/10 µm: 6-7.
Fig. 3.	vl: 200 µm,	vb: 25 µm,	s/10 µm: 6.
Fig. 4.	vl: 194 µm,	vb: 23 µm,	s/10 µm: 6.
Fig. 5.	vl: 180 µm,	vb: 24 µm,	s/10 µm: 7.
Fig. 6.	vl: 174 µm,	vb: 23 µm,	s/10 µm: 7.
Fig. 7.	vl: 170 µm,	vb: 23 µm,	s/10 µm: 7.
Fig. 8.	vl: 158 µm,	vb: 23 µm,	s/10 µm: 6.
Fig. 9.	vl: 154 µm,	vb: 23 µm,	s/10 µm: 7.
Fig. 10.	vl: 152 µm,	vb: 22 µm,	s/10 µm: 7-8.
Fig. 11.	vl: 142 µm,	vb: 22 µm,	s/10 µm: 7-8.
Fig. 12.	vl: 139 µm,	vb: 16 µm,	s/10 µm: 8-9.
Fig. 13.	vl: 137 µm,	vb: 20 µm,	s/10 µm: 6-7.
Fig. 14.	vl: 129 µm,	vb: 20 µm,	s/10 µm: 6-7.

vl = valve length; vb = valve breadth; s/10 µm = number of striae per 10 µm interval

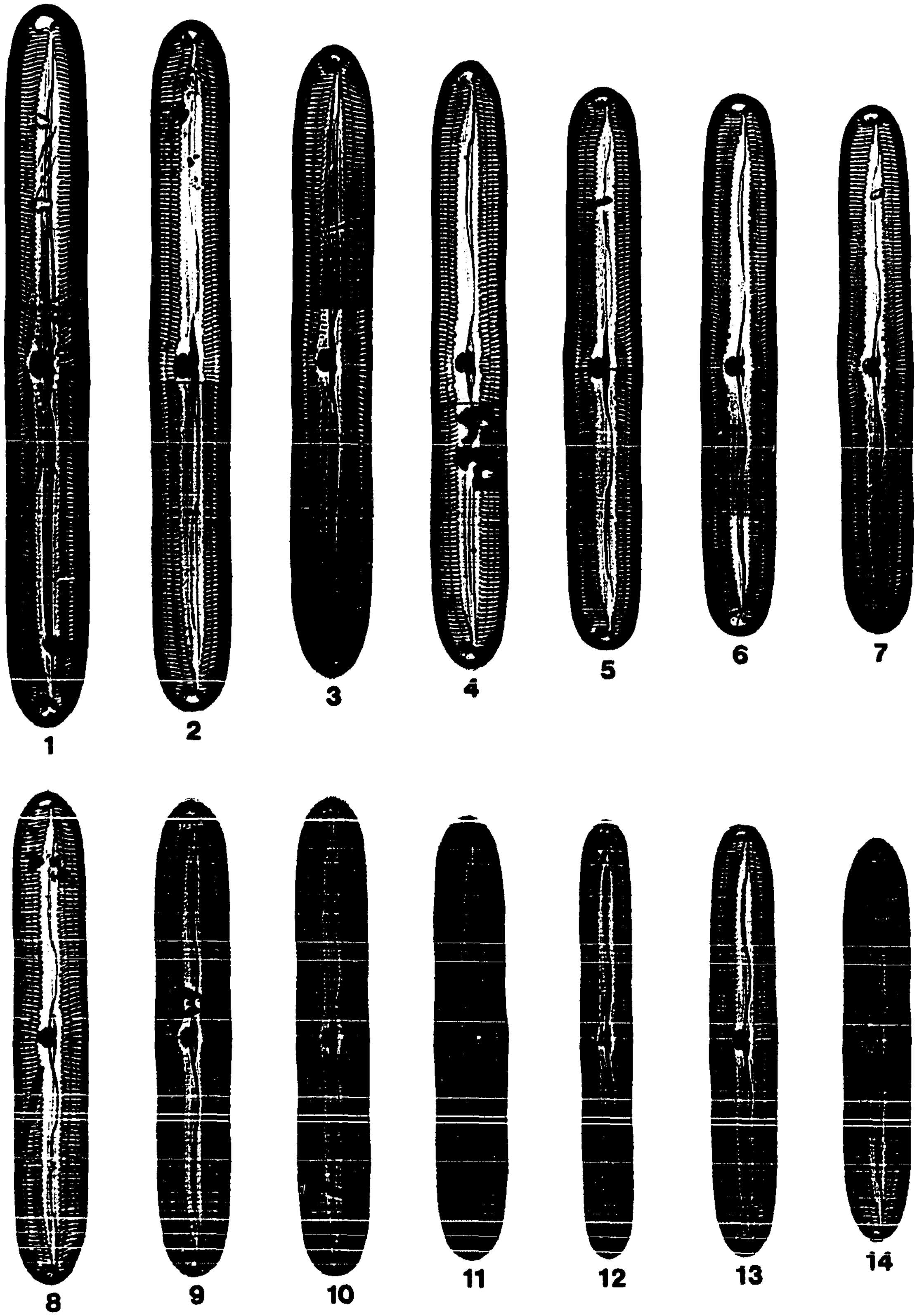
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Plate XLI

Valve structure of *Pinnularia streptoraphe* Cl. var. *streptoraphe* and *Pinnularia ruttneri* Hust. var. *ruttneri*.

Fig. 1. *Pinnularia streptoraphe* Cl. var. *streptoraphe*.
Valve interior. X390. SEM
vl: 194 μm, vb: 29 μm, s/10 μm: 5.

Fig. 2. *Pinnularia ruttneri* Hust. var. *ruttneri*.
Valve exterior. X580. SEM
vl: 165 μm, vb: 23 μm, s/10 μm: 7.

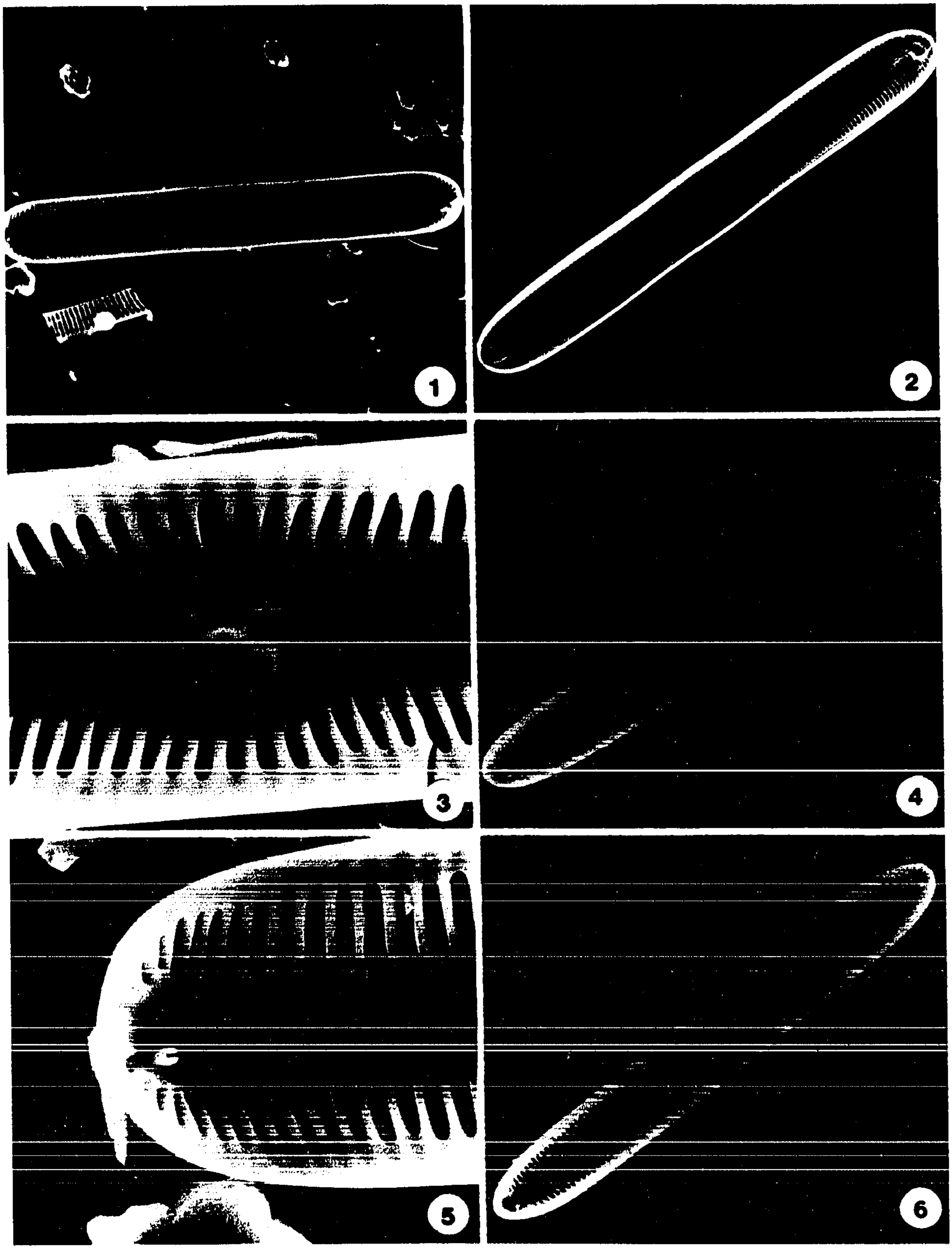
Fig. 3. *Pinnularia streptoraphe* Cl. var. *streptoraphe*.
Central area as viewed from the valve interior.
X2200. SEM

Fig. 4. *Pinnularia ruttneri* Hust. var. *ruttneri*.
Valve interior. X610. SEM
vl: 152 μm, vb: 22 μm, s/10 μm: 7-8.

Fig. 5. *Pinnularia streptoraphe* Cl. var. *streptoraphe*.
Valve apex as viewed from the valve interior.
X2230. SEM

Fig. 6. *Pinnularia ruttneri* Hust. var. *ruttneri*.
Valve interior. X690. SEM
vl: 139 μm, vb: 19 μm, s/10 μm: 7.

vl = valve length; vb = valve breadth; s/10 μm = number of striae per 10 μm interval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Distribution: Found at 3 locations: Dead Man's Lake (Samples #1, 3, 10, 42, and 48), Big Wall Lake (Sample #51), and Three Corner Ponds (Sample #63).

Pinnularia streptoraphe Cl. var. streptoraphe

(Plate XLII)

Valves linear with bluntly rounded apices. Length: 156-216 μm, breadth: 24-33 μm. Axial area one-sixth to one-fourth of the valve breadth. Central area small, asymmetrically rounded. Striae radiate, slightly radiate, or nearly parallel at the central area, slightly radiate, parallel, or slightly convergent at the apices, 4-5 in 10 μm (mean: 5 in 10 μm). Longitudinal bands distinct, band breadth one-third to one-half of the striae length. Raphe moderately to highly complex, apical fissures "question mark" shaped.

The valve interior of a specimen of this taxon was observed with the SEM (Plate XLI, Figs. 1, 3, and 5). The inner raphe fissure is relatively straight (Fig. 1) and is uninterrupted at the central nodule (Figs. 1 and 2). At each polar nodule, a small siliceous thickening occurs at the end of the inner raphe fissure (Figs. 1 and 3). The foramina are relatively large and are positioned near the valve margins (Figs. 1, 3, and 5).

Distribution: Found at 4 locations: Dead Man's Lake (Samples #1, 3, 40, 42, and 43), an exposed lake bed (Sample #2), a Carex mat near Dead Man's Lake (Sample #9), and the Freda Haffner Kettle Hole (Sample #25).

Pinnularia viridis var. intermedia Cl.

(Plate XLIII)

Valves linear with rounded-cuneate apices. Length: 64-131 μm, breadth: 11-18 μm. Axial area one-fourth to one-third of the valve breadth. Central area small,

Plate XLII

Valve structure and variability of
Pinnularia streptoraphe Cl. var. streptoraphe.
X500. p. 121.

Fig. 1.	vl: 200 µm,	vb: 30 µm,	s/10 µm: 5.
Fig. 2.	vl: 200 µm,	vb: 29 µm,	s/10 µm: 5.
Fig. 3.	vl: 196 µm,	vb: 29 µm,	s/10 µm: 5.
Fig. 4.	vl: 179 µm,	vb: 29 µm,	s/10 µm: 5.
Fig. 5.	vl: 178 µm,	vb: 30 µm,	s/10 µm: 5.
Fig. 6.	vl: 169 µm,	vb: 29 µm,	s/10 µm: 5.
Fig. 7.	vl: 164 µm,	vb: 26 µm,	s/10 µm: 5.
Fig. 8.	vl: 157 µm,	vb: 27 µm,	s/10 µm: 5.
Fig. 9.	vl: 156 µm,	vb: 25 µm,	s/10 µm: 5.

vl = valve length; vb = valve breadth; s/10 µm = number of striae per 10 µm interval

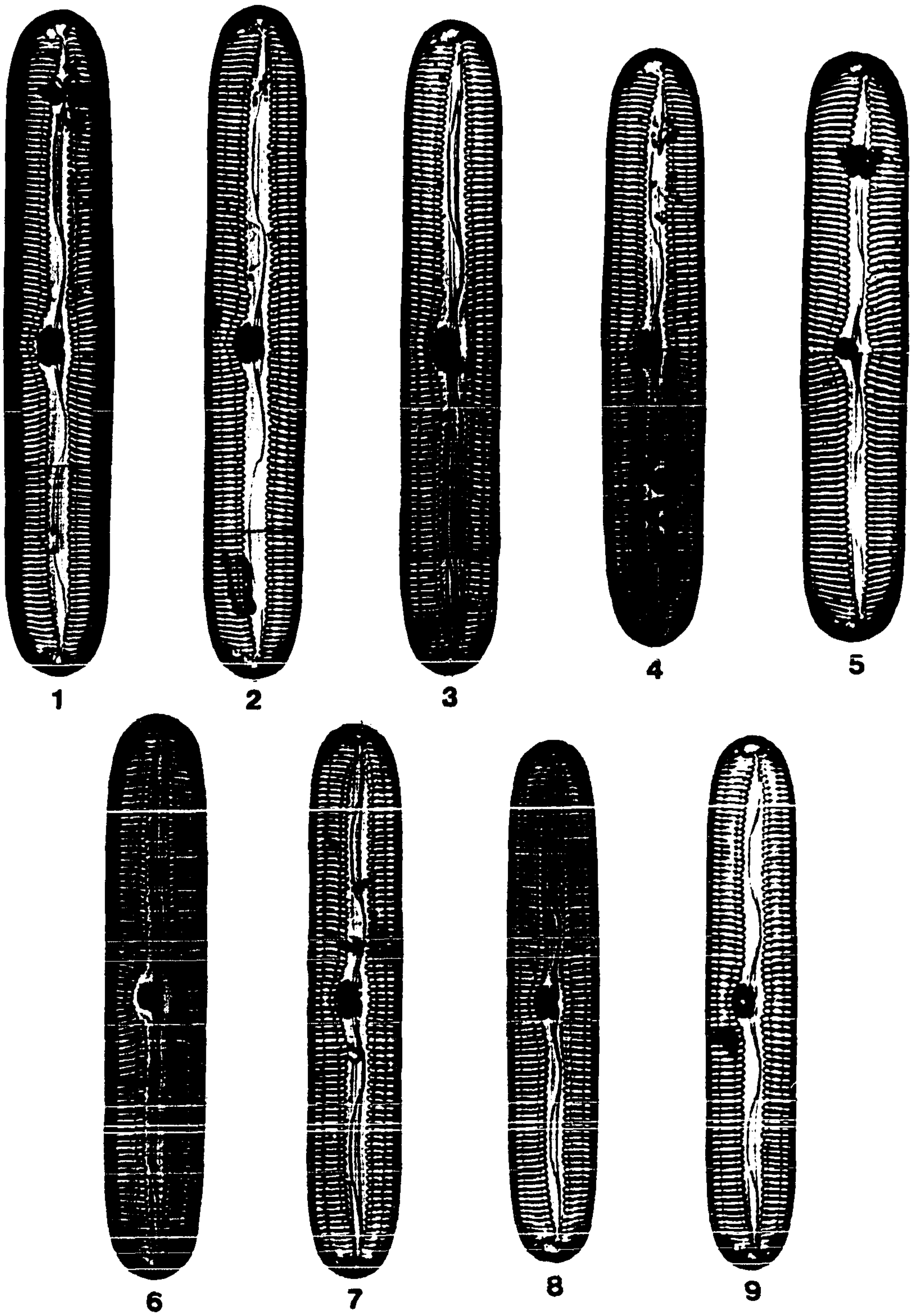
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Plate XLIII

Valve structure and variability of
Pinnularia viridis var. *intermedia* Cl.
X1000. p. 121.

Fig. 1.	vl: 127 µm,	vb: 16 µm,	s/10 µm:	8-9.
Fig. 2.	vl: 112 µm,	vb: 16 µm,	s/10 µm:	7-8.
Fig. 3.	vl: 105 µm,	vb: 15 µm,	s/10 µm:	8.
Fig. 4.	vl: 101 µm,	vb: 14 µm,	s/10 µm:	8.
Fig. 5.	vl: 101 µm,	vb: 14 µm,	s/10 µm:	9.
Fig. 6.	vl: 88 µm,	vb: 13 µm,	s/10 µm:	8-9.
Fig. 7.	vl: 83 µm,	vb: 12 µm,	s/10 µm:	9.
Fig. 8.	vl: 75 µm,	vb: 13 µm,	s/10 µm:	10.
Fig. 9.	vl: 73 µm,	vb: 13 µm,	s/10 µm:	8-9.
Fig. 10.	vl: 68 µm,	vb: 14 µm,	s/10 µm:	9.

vl = valve length; vb = valve breadth; s/10 µm = number of striae per 10 µm interval

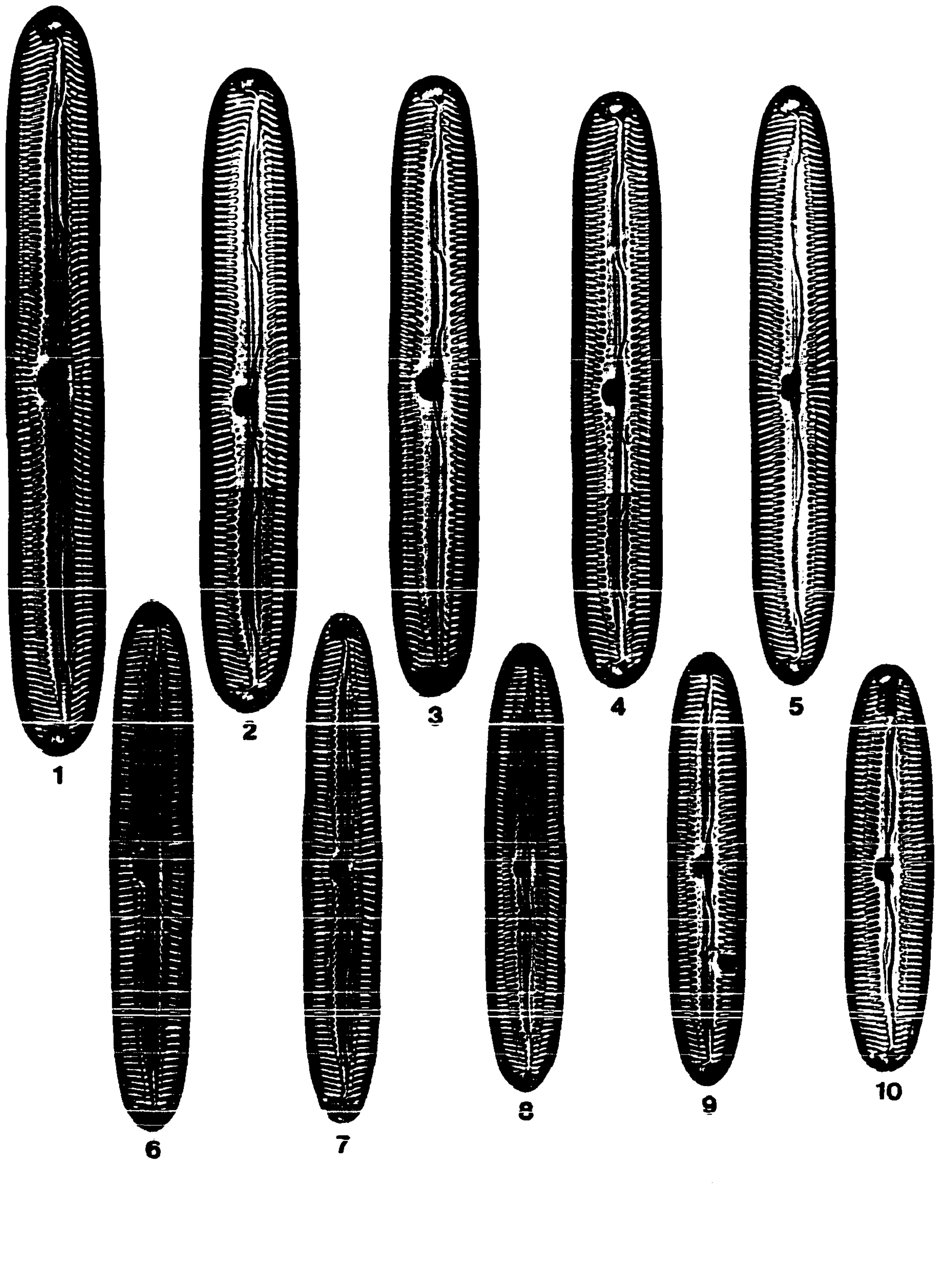

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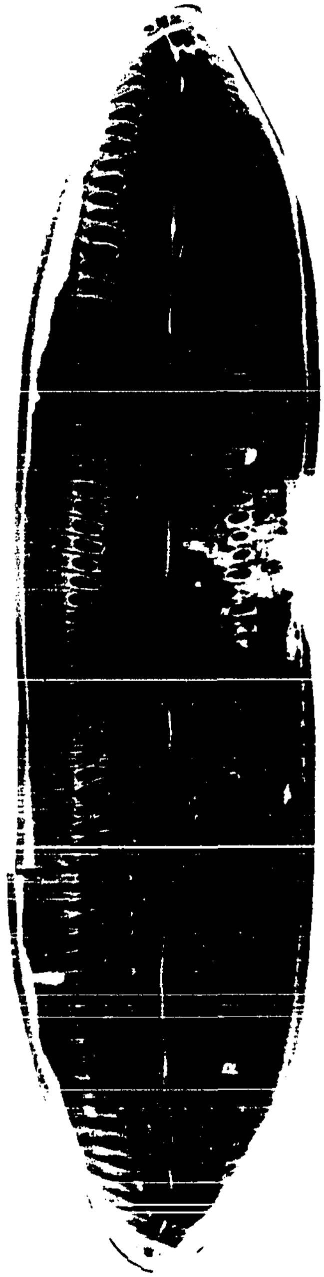
Plate XLIV

Carbon-metal replicas of
Pinnularia viridis var. _intermedia_ Cl.

Fig. 1. _Pinnularia viridis_ var. _intermedia_ Cl.
Carbon-metal replica. X2000. TEM
vl: 84 μm, vb: 14 μm, s/10 μm: 9.

Fig. 2. _Pinnularia viridis_ var. _intermedia_ Cl.
Carbon-metal replica of the tubular striae.
X10000. TEM

vl = valve length; vb = valve breadth; s/10 μm = number of striae per 10 μm interval



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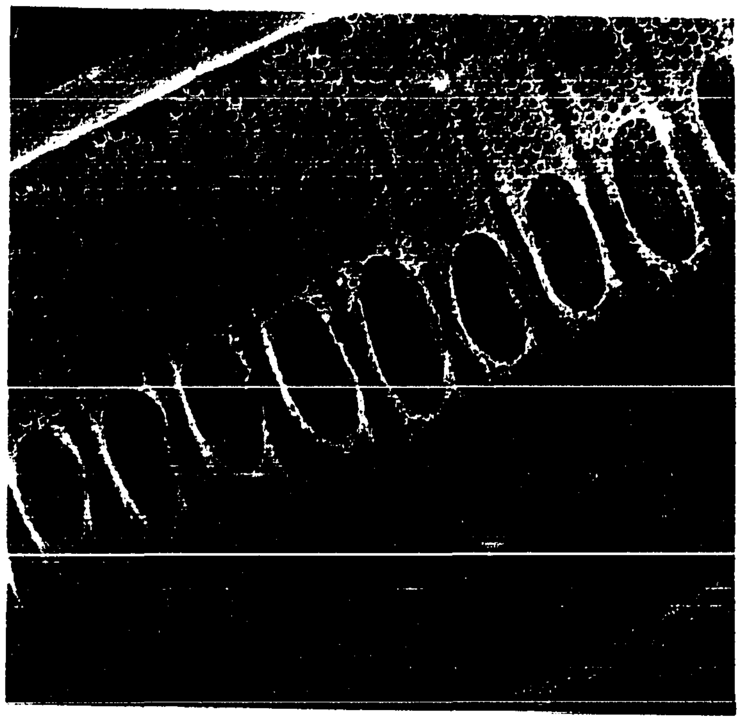

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Plate XLV

Structure of the valve exterior and valve interior of *Pinnularia viridis* var. *intermedia* Cl.

Fig. 1. *Pinnularia viridis* var. *intermedia* Cl.
Valve exterior. X1060. SEM
vl: 61 μm, vb: 11 μm, s/10 μm: 8-9.

Fig. 2. *Pinnularia viridis* var. *intermedia* Cl.
Valve interior. X1040. SEM
vl: 67 μm, vb: 11 μm, s/10 μm: 8.

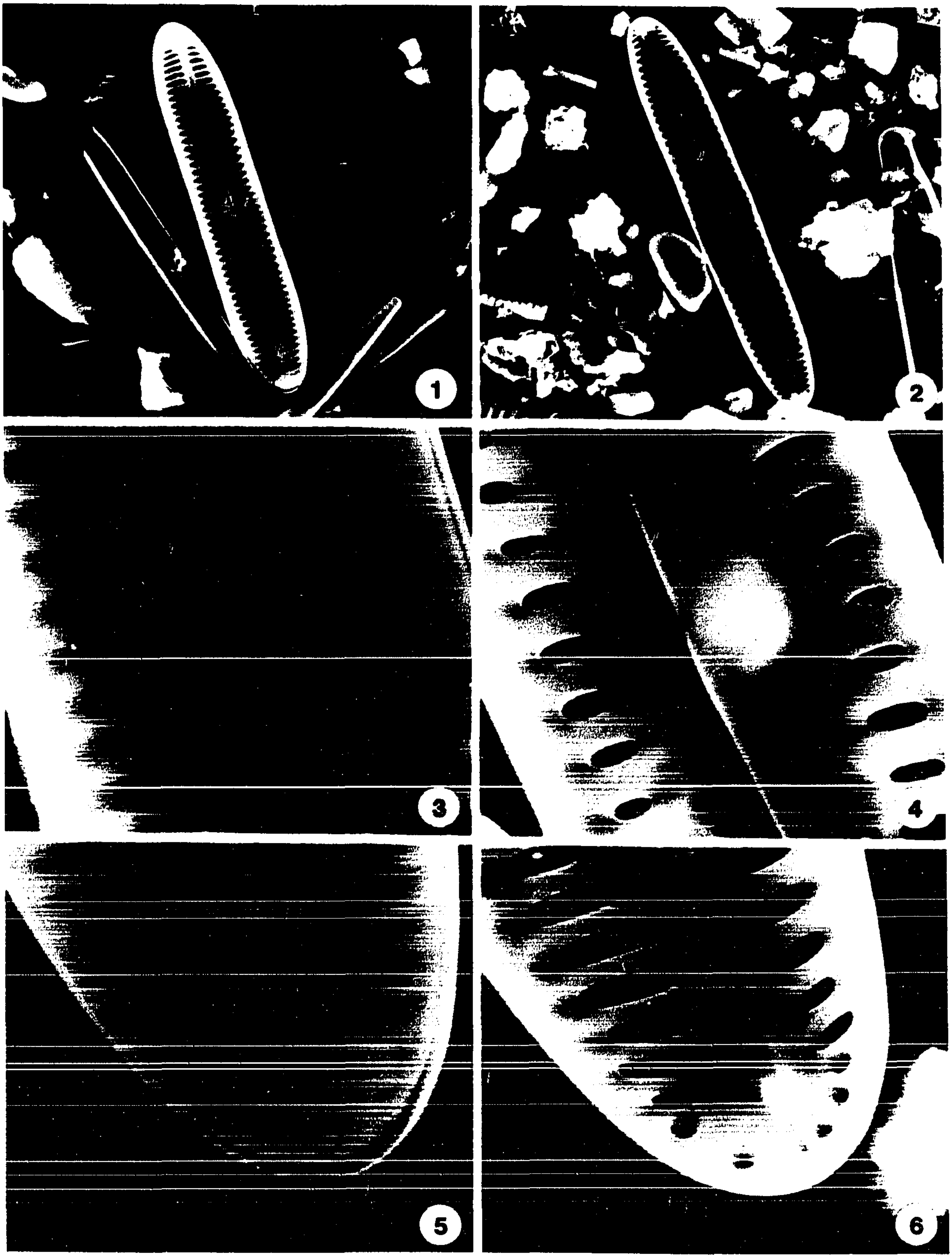
Fig. 3. *Pinnularia viridis* var. *intermedia* Cl.
Central area as viewed from the valve exterior.
X7200. SEM

Fig. 4. *Pinnularia viridis* var. *intermedia* Cl.
Central area as viewed from the valve interior.
X7340. SEM

Fig. 5. *Pinnularia viridis* var. *intermedia* Cl.
Valve apex as viewed from the valve exterior.
X7340. SEM

Fig. 6. *Pinnularia viridis* var. *intermedia* Cl.
Valve apex as viewed from the valve interior.
X7290. SEM

vl = valve length; vb = valve breadth; s/10 μm = number of striae per 10 μm interval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asymmetrically rounded (Figs. 6 and 10), or not clearly differentiated from the axial area (Figs. 2, 4, and 9). Striae slightly radiate to radiate at the central area, parallel, slightly convergent, or convergent at the apices, 7-10 in 10 µm (mean: 9 in 10 µm). Breadth of the longitudinal bands one-fifth to one-half of the length of the striae. Raphe often moderately complex (Figs. 5 and 6), but ranging from slightly complex (Figs. 8 and 10) to highly complex (Figs. 2 and 3). Apical raphe fissures "question mark" shaped.

A carbon-metal replica of a valve of this taxon reveals the tubular nature of the striae (Plate XLIV, Figs. 1 and 2). The foramina span only a portion of the length of the striae, resulting in the appearance of longitudinal bands. Within the foramina, the finely punctate outer walls of the striae are clearly visible (Fig. 2).

The SEM was also used to examine the valve structure of this taxon (Plate XLV). On the exterior valve surface, the tubular striae consist of fields of minute pores (Figs. 3 and 5). The outer raphe fissure is distinctly complex (Fig. 1), its branches terminating at the central area in two pores (Fig. 3). At the apices (Fig. 5), the outer raphe fissure becomes "hook" shaped. On the valve interior, the foramina of the tubular striae are visible near the valve margins (Figs. 2, 4, and 6). The inner raphe fissure is nearly straight and is not interrupted at the central area (Figs. 2 and 4). A small siliceous nodule is present at each end of the inner raphe fissure (Figs. 2 and 6).

<u>Distribution</u>: Found at many locations: ponds and lakes (Samples #1, 3, 10, 19, 27, 32, 40, 42, 48, 51, 63,

64, 65, and 74), creeks and rivers (Samples #20, 24, 26, 41, and 117), the Freda Haffner Kettle Hole (Samples #25, 58, 59, 60, 61, and 62), an exposed lake bed (Sample #2), a *Carex* mat near Dead Man's Lake (Sample #9), Jemmerson Slough (Sample #18), and a borrow pit (Sample #33).

Pinnularia viridis (Nitz.) Ehr. var. *viridis*

(Plate XLVI)

Valves linear, sometimes slightly inflated at the central area. Apices rounded-cuneate, occasionally bluntly rounded. Length: 46-192 µm, breadth: 8-32 µm. Axial area one-seventh to one-third of the valve breadth. Central area typically small, asymmetrically rounded (Figs. 1, 4, and 13), or not well differentiated from the axial area (Figs. 8, 9, and 14), rarely forming a unilateral (Fig. 20) or bilateral fascia. Striae slightly radiate to radiate at the central area, parallel, slightly convergent, or convergent at the apices, 6-11 in 10 µm (mean: 8 in 10 µm). Breadth of the longitudinal bands one-fourth to three-fourths of the length of the striae. Raphe extremely variable, typically slightly (Figs. 10, 11, and 14) or moderately (Figs. 2, 3, and 7) complex, but ranging from highly complex to undulate (Fig. 18) or filamentous (Figs. 17 and 19). Apical raphe fissures "question mark" shaped.

Distribution: Found at many locations: lakes and ponds (Samples #1, 3, 10, 16, 19, 29, 32, 40, 42, 43, 44, 45, 46, 47, 48, 49, 51, 57, 63, 64, 65, and 74), creeks and rivers (Samples #20, 24, 26, 41, 50, 78, 80, 82, 87, 88, 90, 92, 94, 98, 102, 105, 106, 109, 112, 115, 120, 124, 138, 146, 150, 156, 159, and 163), fens (Samples #15, 21, 22, 23, 68, and 69), the Freda Haffner Kettle Hole (Samples #25, 58, 59, 60, 61, and 62), seepage areas (Samples #54 and 70), an exposed lake bed (Sample #2), a *Carex* mat near Dead Man's Lake (Sample #9), Jemmerson Slough (Sample #18), a borrow pit (Sample #33), a pothole near Cayler Prairie (Sample #66), and a drainage pipe (Sample #71).

Plate XLVI

Valve structure and variability of *Pinnularia viridis* (Nitz.) Ehr. var. *viridis*. X500. p. 131.

Fig. 1.	vl: 184 µm,	vb: 31 µm,	s/10 µm: 6-7.
Fig. 2.	vl: 173 µm,	vb: 24 µm,	s/10 µm: 8.
Fig. 3.	vl: 171 µm,	vb: 26 µm,	s/10 µm: 7.
Fig. 4.	vl: 162 µm,	vb: 26 µm,	s/10 µm: 6.
Fig. 5.	vl: 154 µm,	vb: 24 µm,	s/10 µm: 7.
Fig. 6.	vl: 151 µm,	vb: 21 µm,	s/10 µm: 7.
Fig. 7.	vl: 140 µm,	vb: 20 µm,	s/10 µm: 6.
Fig. 8.	vl: 139 µm,	vb: 23 µm,	s/10 µm: 8.
Fig. 9.	vl: 137 µm,	vb: 22 µm,	s/10 µm: 7-8.
Fig. 10.	vl: 121 µm,	vb: 20 µm,	s/10 µm: 7.

vl = valve length; vb = valve breadth; s/10 µm = number of striae per 10 µm interval

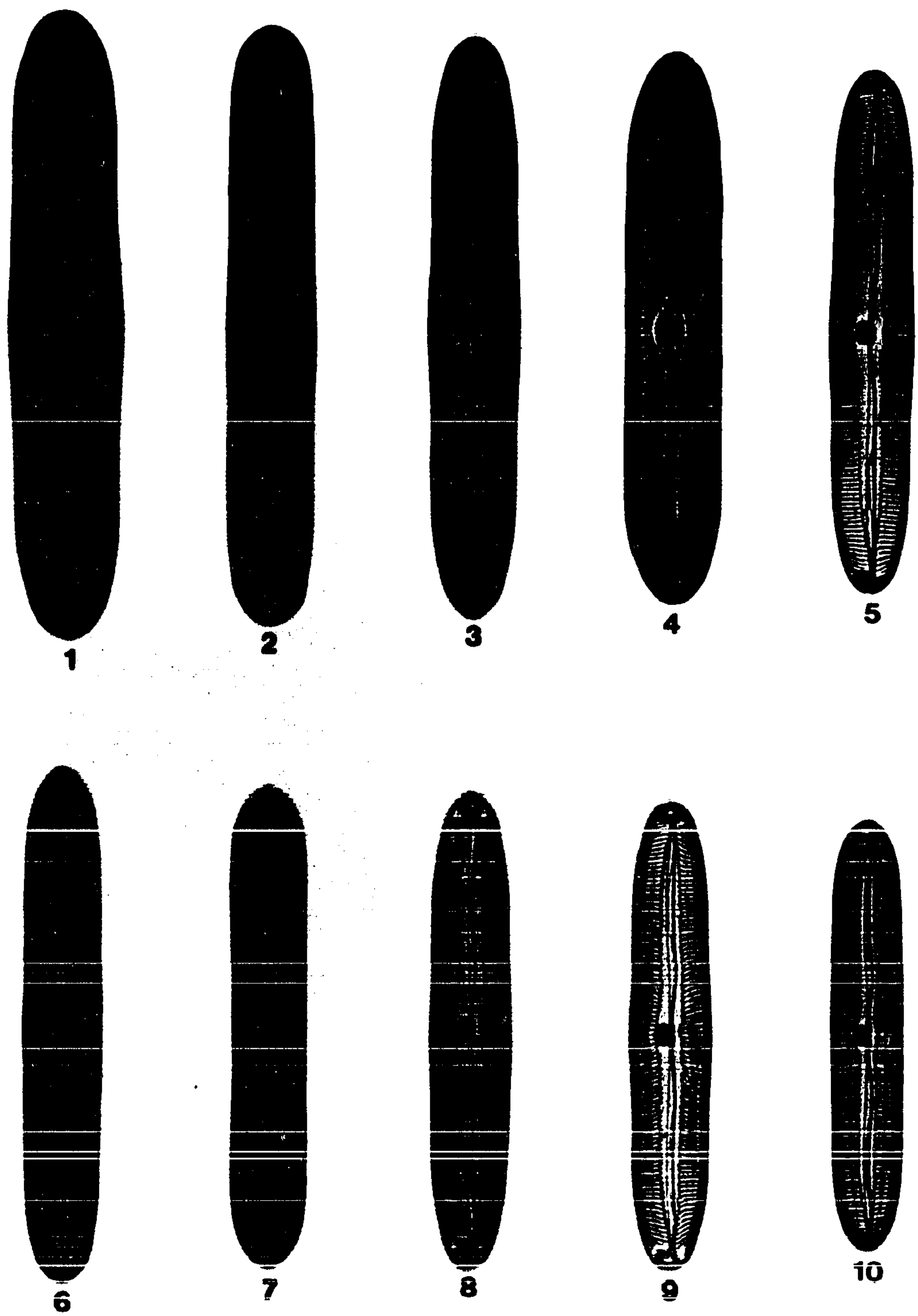
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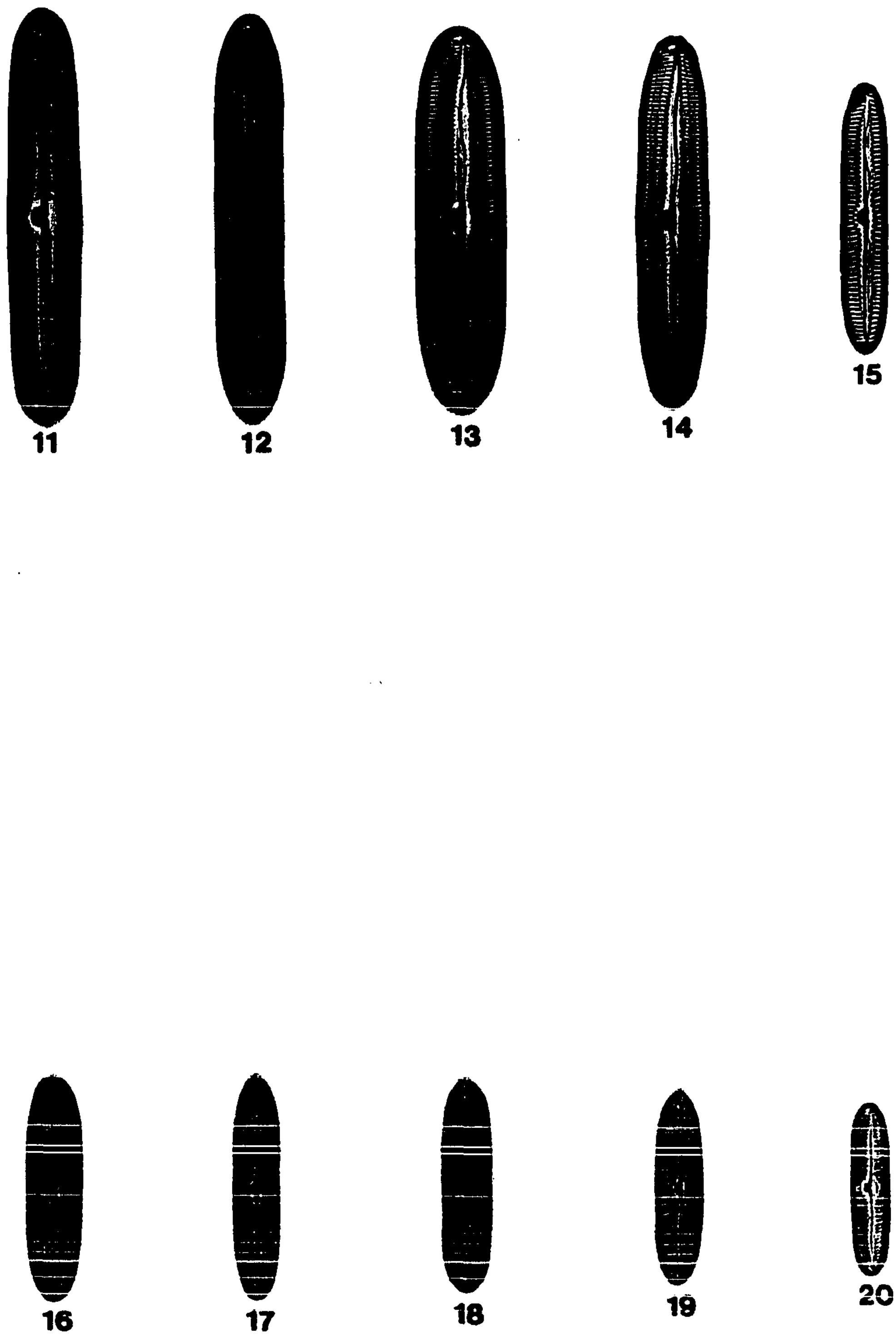
Plate XLVI (continued)

Valve structure and variability of
<u>Pinnularia</u> <u>viridis</u> (Nitz.) Ehr. var. <u>viridis</u>.
X500. p. 131.

Fig. 11.	vl: 120 μm,	vb: 20 μm,	s/10 μm:	8.
Fig. 12.	vl: 118 μm,	vb: 18 μm,	s/10 μm:	6-7.
Fig. 13.	vl: 111 μm,	vb: 25 μm,	s/10 μm:	7-8.
Fig. 14.	vl: 107 μm,	vb: 20 μm,	s/10 μm:	7-8.
Fig. 15.	vl: 80 μm,	vb: 13 μm,	s/10 μm:	7.
Fig. 16.	vl: 64 μm,	vb: 15 μm,	s/10 μm:	9-10.
Fig. 17.	vl: 64 μm,	vb: 13 μm,	s/10 μm:	9.
Fig. 18.	vl: 62 μm,	vb: 14 μm,	s/10 μm:	9.
Fig. 19.	vl: 56 μm,	vb: 14 μm,	s/10 μm:	10.
Fig. 20.	vl: 50 μm,	vb: 10 μm,	s/10 μm:	9.

vl = valve length; vb = valve breadth; s/10 μm = number of striae per 10 μm interval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DISCUSSION

Brevistriatae

Pinnularia acrosphaeria W. Sm. var. *acrosphaeria*

Critical reference: Hustedt, 1930, p. 330, fig. 610.

Original description: Smith, 1853, p. 58, pl. 19, fig. 183.

In most respects, the characteristics of the specimens observed in this study coincide well with those given by Hustedt (1930). Hustedt, however, describes the raphe as filiform, while I have observed it to be filamentous. This disparity may be attributable to the fact that the granularity of the axial area frequently obscures the raphe, thereby making observations of its structure difficult. It is also possible that the raphe may appear filiform in some specimens and filamentous in others, as these two raphe types frequently seem to intergrade. In addition, Hustedt (1930, p. 330, fig. 610) depicts both apical raphe fissures of a given valve as being "comma" shaped. In all of the specimens observed in this study, one fissure has been "comma" shaped and the other somewhat "Y" shaped. In later publications, however, Hustedt (1935; 1938b) recognizes and discusses this asymmetry.

Patrick and Reimer (1966, p. 623, pl. 60, figs. 2 and 3) provide a description and illustration very similar to that of Hustedt (1930), but depict the raphe as filamentous.

Their illustration, like that of Hustedt (1930), shows the apical raphe fissures to be "comma" shaped. Neither Hustedt (1930) nor Patrick and Reimer (1966) mention the occurrence of longitudinal bands on the striae. In my specimens, these bands were frequently indistinct and may, in some cases, have been absent.

Previous reports from Iowa: Reported from the Des Moines River (Drum, 1964), Audleheln pond (Ohl, 1965), Coralville Reservoir (Schmidt and Fee, 1967), two drainage ditches in Story County (Lowe, 1970; 1972b), Ventura Marsh (Begres, 1971), and Dead Man's Lake (Christensen, 1976).

Habitat distribution: Reported from springs (Hustedt, 1935; 1938b; 1942), creeks (Hustedt, 1935), rivers (Hustedt, 1942; 1957), ponds (Hustedt, 1938b; 1942), lakes (Hustedt, 1935; 1938b; 1942; 1949), marshes (Hustedt, 1935), swamps (Hustedt, 1942), and bogs (Skvortzow, 1938).

Geographic distribution: Cosmopolitan. Reported from the conterminous United States (Patrick, 1945; Patrick and Reimer, 1966), Alaska (Patrick and Freese, 1961), the Hawaiian Islands (Hustedt, 1942), Java (Hustedt, 1938b; 1942), Sumatra (Hustedt, 1935; 1938b), the Philippines (Hustedt, 1942), the Sunda Islands (Hustedt, 1942), China (Skvortzow, 1938), the Belgian Congo (Hustedt, 1949), the Alps (Krasske, 1932), Germany (Hustedt, 1957), and Finland (Cleve, 1891).

Ecology: Fresh water form (Boyer, 1916; Patrick and Freese, 1961). Oligohalobous (Hustedt, 1938b; 1957). Oligosaprobous (Hustedt, 1957). Listed as alkalibiontic by Hustedt (1957), but as acidophilous by Cholnoky (1968).

Pinnularia brevicostata Cl. var. brevicostata

Critical reference: Hustedt, 1930, p. 329, fig. 609.

Original description: Cleve, 1891, p. 25, pl. 1, fig. 5.

Only one of the five specimens observed in this study failed to fall within the size ranges cited by Hustedt (1930) and Patrick and Reimer (1966). This specimen was 68 μm in length and 11 μm in breadth. The minimum values for these dimensions, as given by Hustedt and Patrick and Reimer, are 70 μm and 12 μm, respectively. The bilateral fascia observed in my specimens may, in some cases, be absent (Hustedt, 1930; Patrick and Reimer, 1966). All of the specimens observed in this study possessed a slightly undulate raphe similar to that described by Hustedt (1930) and Skvortzow (1938). No specimens with strictly filamentous raphes, like those described by Patrick and Reimer (1966), were found.

Previous reports from Iowa: Reported from a core of the Arend's Kettle Hole (Collins, 1968), Clear Lake (Begres, 1971), and Dead Man's Lake (Christensen, 1976).

Habitat distribution: Reported from springs (Hustedt, 1938b), streams (Foged, 1948; Hustedt, 1930), ponds (Hustedt, 1930; 1938b), lakes (Foged, 1954; 1972; Hustedt, 1935; 1938b; 1942), swamps (Hustedt, 1942), and bogs (Skvortzow, 1938).

Geographic distribution: Cosmopolitan. Reported from the conterminous United States (Patrick, 1945; Patrick and Reimer, 1966), Java (Hustedt, 1938b), Sumatra (Hustedt, 1935; 1938b), the Philippines (Hustedt, 1942), China (Skvortzow, 1938), Bengal (Cleve, 1895), Switzerland (Meister, 1912), the Alps (Krasske, 1932), Denmark (Foged, 1948; 1954), Sweden (Cleve, 1895), Finland (Cleve, 1891; 1895; Meriläinen, 1967), and Greenland (Foged, 1972; 1973).

Ecology: Fresh water form (Cleve, 1895). Oligohalobous (Foged, 1954; Hustedt, 1938b). Acidophilous (Foged, 1972), pH optimum below 6 (Cholnoky, 1968). Current indifferent (Foged, 1948; 1954). Prefers cool water of low mineral content (Patrick and Reimer, 1966).

<u>Pinnularia nodosa</u> (Ehr.) W. Sm. var. <u>nodosa</u>

Critical reference: Hustedt, 1930, p. 330, fig. 611.

Original description: Ehrenberg, 1838, p. 179, pl. 13, fig. 9. (listed as <u>Navicula nodosa</u>)

Transferred to <u>Pinnularia</u>: Smith, 1853, p. 96.

The 8 μm valve breadths which I observed do not conform to the 9-12 μm range of valve breadth given by Hustedt (1930). Otherwise, the specimens examined in this study fit Hustedt's description. Both of the valves which I examined exhibited the triundulate shape typical of the species, but specimens have been described which are biundulate or even linear (Barber, 1976; Bock, 1961). The shape of the valve apices is also variable, with some specimens having rostrate rather than capitate apices (Barber, 1976). The striae bordering the central area may be interrupted to form a fascia as in the specimens I observed, or they may be continuous (Barber, 1976). In some specimens the axial area appears granular, but in others, no granularity is apparent (Barber, 1976).

Barber (1976) feels that the most stable valve feature is the siliceous ridge upon which the raphe rests. This ridge gives the impression of two dark lines, one on each side of the raphe. If the refractive index of the mounting medium is, however, too low, these lines may not be visible (Barber, 1976).

Patrick and Reimer (1966, p. 601, pl. 55, figs. 20 and 21) also provide a description and illustration of this species. Neither the granular appearance of the axial area nor the lines bordering the raphe are mentioned or illustrated. Patrick and Reimer specify that the central valve inflation is broader than those at the apices. Christensen (1976) has, however, observed specimens in which the central inflation is narrower than the apical ones. In other respects, the description provided by Patrick and Reimer closely resembles that given by Hustedt.

Previous reports from Iowa: Reported from Ventura Marsh (Begres, 1971) and Dead Man's Lake (Christensen, 1976).

Habitat distribution: Reported from creeks (Dippel, 1904; Patrick, 1945), rivers (Hustedt, 1957), ponds (Foged, 1972), lakes (Bock, 1961; Foged, 1954; 1972; Meriläinen, 1967), and bogs (Patrick, 1945).

Geographic distribution: Reported from the conterminous United States (Patrick, 1945; Patrick and Reimer, 1966), Alaska (Patrick and Freese, 1961), Germany (Bock, 1961; Dippel, 1904; Hustedt, 1957), the Alps (Krasske, 1932), Denmark (Foged, 1954), the British Isles (Barber, 1976), Finland (Cleve, 1891; Meriläinen, 1967), Spitsbergen (Foged, 1964), and Greenland (Foged, 1972; 1973).

Ecology: Fresh water form (Patrick and Freese, 1961). Oligohalobous - indifferent (Foged, 1954) to halophobous (Foged, 1964; Hustedt, 1957). Oligosaprobous (Hustedt, 1957). Listed by some as acidophilous (Foged, 1954) with a pH optimum around 5 (Cholnoky, 1968), by others as pH indifferent (Foged, 1964; 1972; Hustedt, 1957). Current indifferent (Foged, 1954). Seems to prefer cool water of low mineral content (Patrick and Reimer, 1966).

Distantes

Pinnularia borealis Ehr. var. borealis

Critical reference: Hustedt, 1930, p. 326, fig. 597.

Original description: Ehrenberg, 1841 (1843), p. 420, pl. 1 II, fig. 6; pl. 4 I, fig. 5.

With the exception of the valve breadth and the striae number, all of the specimens which I have observed coincide well with the description of this taxon given by Hustedt (1930). Several of the specimens are narrower than the 8 µm minimum breadth stated by Hustedt, but fall within the range of valve breadths given by Lund (1946) for specimens found in soils. According to Hustedt (1930), the number of striae varies from 4 to 6 in 10 µm, which is a slightly narrower range than the 3 to 7 found in this study.

Carlson (1913) erected a form, forma rectangularis, to encompass specimens with subrectangular valves. The amount of shape variation which I have observed in this species has led me to concur with Bock's (1975) contention that this form should be combined with the species.

Cleve (1895) states that this species intergrades with Pinnularia lata Bréb. Forms intermediate between the two species have also been noted by Boyer (1916) and by Hustedt (1930). The number of specimens which I have examined is insufficient to permit any conclusions on this point.

Previous reports from Iowa: Reported from the Mississippi River near Burlington (Ehrenberg, 1856), the Des Moines River (Drum, 1964; Ehrenberg, 1856; Gudmundson, 1969; 1972), fossil diatomaceous earth (Myers, 1898b), Lake West Okoboji (Collins, 1968; Stoermer, 1963), farm ponds (Ohl, 1965), Dutch Creek (Fee, 1967), drainage ditches in Story County (Lowe, 1970; 1972b), Clear Lake (Begres, 1971), Pillsbury Lake bed (Hungerford, 1972), and Dead Man's Lake (Christensen, 1976).

Habitat distribution: Reported from springs (Hustedt, 1935; 1938b; 1949), creeks and streams (Foged, 1948; Hustedt, 1935; Meister, 1912), rivers (Hustedt, 1957; Patrick and Reimer, 1966), ponds (Foged, 1972; Hare, 1978; Patrick and Reimer, 1966), lakes (Foged, 1954; Hustedt, 1935; 1942; 1949; Meister, 1912), bogs (Foged, 1972; Skvortzow, 1938), soils (Cleve, 1895; Lund, 1946), and moss clumps (Cleve, 1895; Hustedt, 1935; 1938b; Krasske, 1932; Patrick, 1948).

Geographic distribution: Cosmopolitan. Reported from the conterminous United States (Boyer, 1916; Patrick, 1945; Patrick and Reimer, 1966), Alaska (Mc Laughlin and Stone, 1976; Patrick and Freese, 1961), Java (Hustedt, 1938b), Sumatra (Hustedt, 1935), the Philippines (Hustedt, 1942), China (Skvortzow, 1938), the Belgian Congo (Hustedt, 1949), Switzerland (Meister, 1912), the Alps (Krasske, 1932), Germany (Hustedt, 1957), Denmark (Foged, 1948; 1954), Finland (Cleve, 1891), United Kingdom (Hare, 1978), Spitsbergen (Foged, 1964), and Greenland (Foged, 1972; 1973).

Ecology: Fresh water form (Cleve, 1895; Hustedt, 1935). Oligohalobous - indifferent (Foged, 1948; 1954; Hustedt, 1938b; 1957). Oligosaprobous (Hustedt, 1957). Listed by some as pH indifferent (Foged, 1948; 1954; 1964; 1972; Hustedt, 1957), but by Cholnoky (1968) as having a pH optimum below 6. Current indifferent (Foged, 1948; 1954). Prefers cool water of low mineral content (Patrick and Reimer, 1966).

Pinnularia lata (Bréb.) Rabh. var. *lata*

Critical reference: Hustedt, 1930, p. 324, fig. 595.

Original description: Brébisson, 1838, p. 18. (listed as *Frustulia lata*)

Transferred to *Pinnularia*: Rabenhorst, 1853, p. 42.

Only one specimen of this taxon was observed. The complex raphe structure of this specimen is the only characteristic which differs markedly from Hustedt's (1930) description. Hustedt describes the raphe as broad, slightly curved, and not complex. Similarly, Patrick and Reimer (1966) describe the raphe as filamentous. However, Boyer (1916, pl. 30, fig. 23) and Foged (1972, pl. CIII, fig. 6) illustrate specimens in which the raphe appears to be somewhat complex.

The relationship between this taxon and *Pinnularia borealis* Ehr. is unclear. The only striking differences between the specimens of *Pinnularia borealis* and *P. lata* examined in this study involve valve size and raphe structure. The valves of *Pinnularia borealis* were much smaller and lacked the complex raphe structure of *P. lata*.

Dodd and Stoermer (1962) have reported *Pinnularia lata* from a moss-lichen habitat in Boone County, Iowa. In my opinion, the specimen which they illustrate more closely resembles specimens of *Pinnularia borealis* than *P. lata*.

Previous reports from Iowa: Reported from a moss-lichen habitat at Ledges State Park (Dodd and Stoermer, 1962).

Habitat distribution: Reported from brooks (Hustedt, 1930), ponds (Foged, 1972; Hustedt, 1930), lakes (Foged, 1972; Patrick and Reimer, 1966), and bogs (Foged, 1972; Patrick and Reimer, 1966).

Geographic distribution: Reported from the conterminous United States (Patrick and Reimer, 1966), Alaska (Patrick and Freese, 1961), Finland (Cleve, 1891), Spitsbergen (Foged, 1964), and Greenland (Foged, 1972; 1973).

Ecology: Fresh water form (Cleve, 1895; Patrick and Freese, 1961). Oligohalobous - halophobous (Foged, 1964). Acidophilous (Foged, 1964; 1972), pH optimum between 5 and 6 (Cholnoky, 1968). Prefers cool water of low mineral content (Patrick and Reimer, 1966).

Parallelistriatae

Pinnularia leptosoma Grun. var. leptosoma

Critical reference: Hustedt, 1930, p. 316, fig. 567.

Original description: Grunow in Van Heurck, 1880, pl. 12, fig. 29. (listed as Navicula leptosoma)

Transferred to Pinnularia: Cleve, 1895, p. 74.

According to Hustedt (1930), valves of this taxon are 32-40 µm long, 4-5 µm wide, and have very narrow axial areas and slightly radiate striae. Most of the specimens observed in this study differed from this description to some extent. Many were less than 32 µm long, or slightly greater than 5 µm wide. In one specimen, the axial area, which normally occupies one-fourth to one-fifth of the valve breadth, was expanded to one-third of the valve breadth. The striae angle was also found to be somewhat variable. In some specimens the striae were all slightly radiate as Hustedt illustrates, while in others the apical striae were parallel or even slightly convergent. This taxon may be confused with certain species of Caloneis. The absence of the fine longitudinal bands typical of Caloneis indicates that this taxon probably belongs in the genus Pinnularia.

Previous reports from Iowa: None.

Habitat distribution: Reported from springs (Hustedt, 1938a), rivers (Hustedt, 1957), waterfalls (Hustedt, 1938a), ponds (Hustedt, 1938a; 1949), lakes (Hustedt, 1938a; 1942), and moss clumps (Krasske, 1932).

Geographic distribution: Cosmopolitan. Reported from the conterminous United States (Boyer, 1916), Java (Hustedt, 1938a; 1942), Sumatra (Hustedt, 1938a), the Philippines (Hustedt, 1942), the Belgian Congo (Hustedt, 1949), the Alps (Krasske, 1932), Germany (Hustedt, 1957), Finland (Cleve, 1891), and Greenland (Foged, 1973).

Ecology: Fresh water form (Boyer, 1916; Cleve, 1895). Oligohalobous - halophobous to indifferent (Hustedt, 1938a) or halophobous (Hustedt, 1957). Saproxenous (Hustedt, 1957). Listed as alkaliphilous by Hustedt (1957), but with a pH optimum around 5.5 by Cholnoky (1968).

Pinnularia species #1

This taxon seems to be most closely related to Pinnularia undulata Greg. (Hustedt, 1930, p. 315, fig. 565). However, my specimens differ from P. undulata in several respects. Unlike the triundulate valves of P. undulata, the valves of this taxon are linear. The valve lengths also differ, valves of P. undulata being, in general, larger than those of this taxon. In addition, the striae number of 13 to 18 in 10 µm is significantly lower than the 22 in 10 µm reported for P. undulata. Pinnularia undulata var. subundulata Grun., which has 18 to 21 striae in 10 µm and less distinctly undulate margins, also appears to be closely related to this taxon. The taxonomic position of the specimens observed in this study is, however, still uncertain.

Capitatae

Pinnularia biceps Greg. var. biceps

Critical reference: Patrick and Reimer, 1966, p. 599, pl. 55, figs. 14 and 15.

Original description: Gregory, 1856, p. 8, pl. 1, fig. 28.

Patrick and Reimer (1966) describe the valve apices of this taxon as distinctly capitate, but in some of my specimens the apices are subcapitate. The raphe may be a narrow filament, as described by Patrick and Reimer (1966), but may also be filiform. In other respects, the specimens observed in this study coincide well with the description given by Patrick and Reimer (1966).

Pinnularia biceps seems to be related to the form I have designated as Pinnularia interrupta W. Sm. The valves of P. biceps are, however, larger, broader, and more coarsely striated than those of P. interrupta. Although some authors have considered P. biceps to be a form of P. interrupta, the absence, in my collections, of specimens intermediate in size and striae number has prompted me to retain them as separate entities.

Pinnularia biceps also appears to be related to

Pinnularia braunii (Grun.) Cl. Specimens of these species are quite similar in length, breadth, and striae number, but differ somewhat in valve shape and axial area breadth, P. braunii being more convex and having a broader axial area than P. biceps. Specimens of P. braunii with more linear margins and narrower axial areas than are typical for the species (Plate XIV, Figs. 3, 5, and 7) seem to intergrade with P. biceps.

Previous reports from Iowa: Reported from the Coralville Reservoir (Schmidt and Fee, 1967), Ventura Marsh (Begres, 1971), Pillsbury Lake bed (Hungerford, 1972), Dead Man's Lake (Christensen, 1976), and the Skunk River (Beckert, 1977).

Habitat distribution: Reported from lakes (Meister, 1912) and bogs (Foged, 1973).

Geographic distribution: Reported from the conterminous United States (Patrick and Reimer, 1966), Switzerland (Meister, 1912), the British Isles (Gregory, 1856), and Greenland (Foged, 1973).

Ecology: Fresh water form (Cleve, 1895; Patrick and Reimer, 1966). Seems to prefer water of low mineral content (Patrick and Reimer, 1966).

Pinnularia braunii (Grun.) Cl. var. braunii

Critical reference: Hustedt, 1930, p. 319, fig. 577.

Original description: Grunow, 1876, in Schmidt et al., 1874-1959, pl. 45, figs. 77 and 78. (listed as Navicula brauniana)

Adoption of the name braunii: Grunow in Van Heurck, 1880, p. 79, pl. 6, fig. 21.

Transferred to Pinnularia: Cleve, 1895, p. 75.

Specimens of this taxon are slightly more coarsely striated than those described by Hustedt (1930), having 10-11 striae in 10 μm rather than 11-12. Otherwise, these specimens coincide well with Hustedt's description.

The most variable features of this taxon seem to be the valve outline and the structure of the axial area. The highly convex valves typical of the species seem to intergrade with more linear forms. In some specimens, the axial area begins to expand near the apices and broadens rapidly as it approaches the central area. In others, the expansion of the axial area is very gradual, becoming rapid only in the vicinity of the central area. Forms which are nearly linear and have more narrow axial areas seem to intergrade with _Pinnularia_ _biceps_.

Previous _reports_ _from_ _Iowa_: Reported from a farm pond (Ohl, 1965) and Dead Man's Lake (Christensen, 1976).

Habitat _distribution_: Reported from an artesian well (Boyer, 1916), rivers (Hustedt, 1942; 1957), ponds (Hustedt, 1942; 1949), lakes (Hustedt, 1942; 1949; Meriläinen, 1967), a _Sphagnum_ pool (Hustedt, 1938a), and bogs (Meister, 1912; Skvortzow, 1938).

Geographic _distribution_: Cosmopolitan. Reported from the conterminous United States (Boyer, 1916; Patrick and Reimer, 1966), Java (Hustedt, 1938a; 1942), Bali (Hustedt, 1938a; 1942), Sumatra (Hustedt, 1938a), the Philippines (Hustedt, 1942), the Sunda Islands (Hustedt, 1938a), China (Skvortzow, 1938), the Belgian Congo (Hustedt, 1949), Switzerland (Meister, 1912), Germany (Hustedt, 1957), and Finland (Cleve, 1891; Meriläinen, 1967).

Ecology: Fresh water form (Cleve, 1895). Oligohalobous - halophobous (?) (Hustedt, 1957) or halophobous to indifferent (Hustedt, 1938a). Oligosaprobous

(Hustedt, 1957). Listed as pH indifferent by Hustedt (1957), but with an optimal pH below 6 by Cholnoky (1968). Seems to prefer cool water of low mineral content (Patrick and Reimer, 1966).

Pinnularia interrupta W. Sm. var. *interrupta*

Critical reference: Hustedt, 1930, p. 317, fig. 573.

Original description: Smith, 1853, p. 59, pl. 19, fig. 184.

The observed length range of 28-35 μm represents a slight extension of the 30-80 μm range previously reported for this species (Hustedt, 1930). However, the breadth range of 6-7 μm represents a considerable departure from the 9-16 μm range given by Hustedt, but closely approximates the 5-6 μm breadth range of *P. interrupta* fo. *minutissima* Hust. Although referred to in the species description as capitate (Hustedt, 1930), the valve apices were occasionally observed to be subcapitate.

The specimens examined in this study possess characteristics of both *Pinnularia interrupta* and *P. interrupta* fo. *minutissima*. Some specimens fell into the 17-30 μm length range of *P. interrupta* fo. *minutissima*, while others fell into the 30-80 μm range of *P. interrupta*. All of the observed valve breadths were more closely aligned with those described for *P. interrupta* fo. *minutissima* than with those described for *P. interrupta*. Since the form and the species thus appear to intergrade, I have chosen to include all of the observed specimens within the scope of the species.

The data collected in this study are not sufficiently adequate to permit conclusions regarding the relationship of _P. interrupta_ to _P. biceps_, the necessary intermediates in size and form having not been encountered. _Pinnularia interrupta_ does, however, appear to be closely related to _P. mesolepta_ (Ehr.) W. Sm., but differs in having linear rather than triundulate margins.

Previous reports from Iowa: Reported from the Des Moines River (Drum, 1964; Starrett and Patrick, 1952) and a farm pond (Ohl, 1965).

Habitat distribution: Reported from springs (Hustedt, 1935; 1938a), streams and brooks (Foged, 1948; Hustedt, 1935), rivers (Hustedt, 1957), ponds (Foged, 1972; Hustedt, 1942; Patrick, 1945), lakes (Foged, 1954; 1972; Hustedt, 1935; 1942; 1949; Meriläinen, 1967; Patrick, 1945), and marshes (Hustedt, 1935; 1942).

Geographic distribution: Cosmopolitan. Reported from the conterminous United States (Patrick, 1945), Alaska (Patrick and Freese, 1961), Java (Hustedt, 1938a), Sumatra (Hustedt, 1935; 1938a), the Philippines (Hustedt, 1942), the Belgian Congo (Hustedt, 1949), the Alps (Krasske, 1932), Germany (Hustedt, 1957), Switzerland (Meister, 1912), Denmark (Foged, 1948; 1954), Finland (Meriläinen, 1967), Spitsbergen (Foged, 1964), and Greenland (Foged, 1972; 1973).

Ecology: Fresh to brackish water form (Patrick and Freese, 1961). Oligohalobous - indifferent (Foged, 1948; 1954; Hustedt, 1938a; 1957). Saproxenous (Hustedt, 1957). Listed by some as acidophilous (Foged, 1948; 1954), others as pH indifferent (Foged, 1964; 1972; Hustedt, 1957), and by Cholnoky (1968) as having a pH optimum above 7. Current indifferent (Foged, 1948; 1954).

Pinnularia mesolepta fo. _angusta_ Cl.

Critical reference: Patrick and Reimer, 1966, p. 601, pl. 55, fig. 19.

Original description: Cleve, 1895, p. 76.

Patrick and Reimer (1966) describe this taxon as triundulate, but some of the specimens observed in this study were biundulate or almost linear. All of the specimens which I observed were shorter than the 65-80 μm length range and narrower than the 9-10 μm breadth range described by Patrick and Reimer. Skvortzow (1938) has, however, reported specimens similar in length and breadth to those observed in this study. The observed range of striae numbers (9-12 in 10 μm) represents an extension of the 10-13 range given in Patrick and Reimer's description. According to Patrick and Reimer, the axial area occupies approximately one-fourth of the valve breadth. Specimens were observed in this study which had axial areas as broad as one-third of the valve breadth or as narrow as one-sixth of the valve breadth.

Previous reports from Iowa: None.

Habitat distribution: Reported from bogs (Skvortzow, 1938) and small pools (Foged, 1973).

Geographic distribution: Reported from the conterminous United States (Patrick and Reimer, 1966), China (Skvortzow, 1938), and Greenland (Foged, 1973).

Ecology: Seems to prefer circumneutral water which is low in mineral content (Patrick and Reimer, 1966).

Pinnularia mesolepta (Ehr.) W. Sm. var. *mesolepta*

Critical reference: Hustedt, 1930, p. 319, fig. 575a.

Original description: Ehrenberg, 1841 (1843), p. 419, pl. 4 II, fig. 4. (listed as *Navicula mesolepta*)

Transferred to _Pinnularia_: Smith, 1853, p. 58, pl. 19, fig. 182.

The observed length range of 27-37 µm represents an extension of the 30-65 µm range previously reported for this species (Hustedt, 1930). The range of valve breadths (6-7 µm) encountered in this study is not encompassed by the 9-11 µm range given by Hustedt (1930). In all other aspects, the specimens which I have examined conform to published descriptions.

The close relationship between this taxon and _Pinnularia interrupta_ W. Sm. has been noted by Cleve (1895) and also by Hustedt (1930). More subtly undulate forms of _P. mesolepta_ are difficult to distinguish from _P. interrupta_ and the data accumulated during this study indicate that these two taxa are virtually indistinguishable on the basis of characteristics other than valve shape. It is therefore quite possible that these species intergrade. This possibility was also recognized by Hustedt (1930) who felt that _P. mesolepta_ could perhaps be interpreted as a triundulate variant of _P. interrupta_. I am, as yet, undecided on this matter and have elected to treat these forms as separate species.

Previous reports from Iowa: Reported from Dead Man's Lake (Christensen, 1976).

Habitat distribution: Reported from springs (Hustedt, 1938a), creeks and streams (Foged, 1948; Hustedt, 1938a), rivers (Hustedt, 1957), ponds (Foged, 1972; Hustedt, 1938a; 1942; 1949; Krasske, 1932), lakes (Foged, 1954; 1972; Hustedt, 1938a; 1949; Meriläinen, 1967), sloughs (Krasske, 1932), and bogs (Skvortzow, 1938).

Geographic distribution: Cosmopolitan. Reported from the conterminous United States (Boyer, 1916; Patrick and Reimer, 1966), Alaska (Patrick and Freese, 1961), Java (Hustedt, 1938a; 1942), Bali (Hustedt, 1938a), Sumatra (Hustedt, 1938a), the Sunda Islands (Hustedt, 1942), China (Skvortzow, 1938), the Belgian Congo (Hustedt, 1949), the Alps (Krasske, 1932), Switzerland (Meister, 1912), Germany (Dippel, 1904; Hustedt, 1957), Denmark (Foged, 1948; 1954), Finland (Cleve, 1891; Meriläinen, 1967), Spitsbergen (Foged, 1964), and Greenland (Foged, 1972; 1973).

Ecology: Fresh water form (Boyer, 1916; Cleve, 1895; Patrick and Freese, 1961; Patrick and Reimer, 1966). Oligohalobous - indifferent (Foged, 1948; 1954; Hustedt, 1957). Oligosaprobous (Hustedt, 1957). Listed by some as pH indifferent (Foged, 1948; 1954; 1964; 1972; Hustedt, 1938a; 1957), but by Cholnoky (1968) as having a pH optimum around or below 6. Current indifferent (Foged, 1948; 1954). Seems to prefer water of low mineral content (Patrick and Reimer, 1966).

Pinnularia subcapitata Greg. var. subcapitata

Critical reference: Patrick and Reimer, 1966, p. 596, pl. 55, figs. 8-10.

Original description: Gregory, 1856, p. 9, pl. 1, fig. 30.

The valve apices of my specimens vary somewhat from the subcapitate to capitate apices reported for the species (Patrick and Reimer, 1966). Most of the specimens exhibited rostrate apices, but the shapes varied from subrostrate to subcapitate. Specimens with wedge-shaped, rounded apices have also been reported (Hustedt, 1949).

According to Patrick and Reimer (1966), members of this species are 24-50 μm long, 4-6 μm wide, and have 12-13 striae in 10 μm. The lengths (16-48 μm), breadths (4-7 μm), and striae numbers (11-15 in 10 μm) observed in this study represent extensions of these ranges.

Previous reports from Iowa: Reported from Excelsior Fen (Shobe et al., 1963), the Arend's Kettle Hole (Collins, 1968), and Dead Man's Lake (Christensen, 1976).

Habitat distribution: Reported from springs (Hustedt, 1935; 1938a), creeks and streams (Foged, 1948; Hustedt, 1938a), rivers (Hustedt, 1957), waterfalls (Hustedt, 1938a), ponds (Hare, 1978; Hustedt, 1938a), lakes (Bock, 1961; Foged, 1954; Hustedt, 1935; 1942; 1949; Meister, 1912; Meriläinen, 1967; Patrick, 1945), soils (Lund, 1946), moss clumps (Krasske, 1932), and bogs (Skvortzow, 1938).

Geographic distribution: Cosmopolitan. Reported from the conterminous United States (Boyer, 1916; Patrick, 1945; Patrick and Reimer, 1966), Java (Hustedt, 1938a), Sumatra (Hustedt, 1935; 1938a), the Philippines (Hustedt, 1942), China (Skvortzow, 1938), the Belgian Congo (Hustedt, 1949), the Alps (Krasske, 1932), Switzerland (Meister, 1912), Germany (Bock, 1961; Hustedt, 1957), the United Kingdom (Hare, 1978), Denmark (Foged, 1948; 1954), Finland (Meriläinen, 1967), Spitsbergen (Foged, 1964), and Greenland (Foged, 1973).

Ecology: Fresh water form (Boyer, 1916; Cleve, 1895; Hustedt, 1930). Oligohalobous - indifferent (Foged, 1948; 1954; Hustedt, 1957). Saproxenous (Hustedt, 1957). Listed by some as pH indifferent (Foged, 1954; 1964; Hustedt, 1957), but by Cholnoky (1968) as having a pH optimum between 5.5 and 5.8. Rheophilous (Foged, 1954) to rheobiontic (?) (Foged, 1948). Krenophil (spring-loving form) (Hustedt, 1938a). Prefers water of low mineral content (Patrick and Reimer, 1966).

Divergentes

Pinnularia abaujensis (Pant.) Ross var. *abaujensis*

Critical reference: Patrick and Reimer, 1966, p. 612, pl. 58, figs. 1 and 2.

Original description: Brébisson, 1838, p. 19. (listed as *Frustulia acrosphaeria*)

Transferred to Pinnularia: Rabenhorst, 1853, p. 45, pl. 6, fig. 36.

Described as Navicula abaujensis: Pantocsek, 1889, p. 41, pl. 3, fig. 54.

Transferred to Pinnularia: Ross, 1947, p. 199, pl. 10, fig. 1.

The valve shape of this taxon varies from distinctly lanceolate to almost linear. Patrick and Reimer (1966) describe this taxon as being 50-140 µm long with 9-13 striae in 10 µm. The observed lengths (35-82 µm) and striae numbers (7-12 in 10 µm) represent extensions of the prescribed ranges.

This taxon is frequently referred to in the literature as Pinnularia gibba Ehr. I have combined information for P. gibba with that for P. abaujensis in the distributional and ecological data which follow.

Previous reports from Iowa: Reported from Dead Man's Lake (Christensen, 1976), fossil diatomaceous earth (Myers, 1898b), soils (Reimer, 1970), and Lake West Okoboji (Stoermer, 1963).

Habitat distribution: Reported from springs (Hustedt, 1935; 1938b), brooks and streams (Foged, 1948; Hustedt, 1935; 1938b), rivers (Hustedt, 1942; 1957), ponds (Foged, 1972; Hustedt, 1942), lakes (Foged, 1954; 1972; Hustedt, 1935; 1942; 1949), waterfalls (Hustedt, 1938b), marshes (Hustedt, 1942), heaths (Hustedt, 1938b), bogs (Krasske, 1932; Skvortzow, 1938), and caves (Hustedt, 1938b).

Geographic distribution: Cosmopolitan. Reported from the conterminous United States (Boyer, 1916; Patrick, 1945; Patrick and Reimer, 1966), Alaska (Patrick and Freese, 1961), the Hawaiian Islands (Hustedt, 1942), Java (Hustedt, 1938b), Bali (Hustedt, 1938b), Sumatra (Hustedt, 1935; 1938b), the Philippines (Hustedt, 1942), China (Skvortzow, 1938), the Belgian Congo (Hustedt, 1949), the Alps (Krasske, 1932), Switzerland (Meister, 1912), Germany (Bock, 1961; Dippel, 1904; Hustedt, 1957), Denmark (Foged, 1948; 1954), Spitsbergen (Foged, 1964), and Greenland (Foged, 1972; 1973).

Ecology: Fresh water form (Boyer, 1916; Cleve, 1895; Hustedt, 1930). Oligohalobous - indifferent (Hustedt, 1938b; 1957). Oligosaprobous (Hustedt, 1957). Sometimes listed as acidophilous (Foged, 1948; 1954), pH optimum around 6 (Cholnoky, 1968), other times as pH indifferent (Foged, 1964; 1972; Hustedt, 1957). Current indifferent (Foged, 1948; 1954). Krenophil (spring-loving form) (Hustedt, 1938b). Widely distributed in waters of low mineral content (Patrick and Reimer, 1966).

Pinnularia abaujensis var. *subundulata* (A. Mayer *ex* Hust.) Patr.

Critical reference: Patrick and Reimer, 1966, p. 614, pl. 58, fig. 5.

Original description: Mayer *ex* Hustedt, 1930, p. 327, fig. 601. (listed as *Pinnularia gibba* fo. *subundulata*)

Transferred to *Pinnularia abaujensis*: Patrick and Reimer, 1966, p. 614, pl. 58, fig. 5.

Patrick and Reimer (1966) describe this taxon as having triundulate margins and a transverse (bilateral) fascia. The specimens which I have examined were either very slightly undulate or linear. Although frequently a bilateral fascia, the central area may also be a unilateral fascia or an elliptical hyaline space. The prescribed ranges of length, breadth, and striae number, as given by Patrick and Reimer (1966), are: length: 50-140 μm, breadth: 7-13 μm, and striae number: 10-13 in 10 μm. The lengths (32-94 μm), breadths (6-14 μm), and striae numbers (9-14 in 10 μm) observed in this study represent expansions of the prescribed ranges. This variety appears to intergrade extensively with more linear specimens of the nominate variety.

This variety is frequently referred to in the literature as Pinnularia gibba fo. subundulata Mayer. I have combined information for P. abaujensis var. subundulata with that for P. gibba fo. subundulata in the distributional and ecological data that follow.

Previous reports from Iowa: Reported from the Skunk River (Shobe, 1967), drainage ditches in Story County (Lowe, 1970; 1972a; 1972b), and Dead Man's Lake (Christensen, 1976).

Habitat distribution: Reported from springs (Hustedt, 1938b), streams (Foged, 1948), ponds (Hustedt, 1938b), lakes (Foged, 1954), and bogs (Skvortzow, 1938).

Geographic distribution: Reported from the conterminous United States (Patrick and Reimer, 1966), Java (Hustedt, 1938b), Sumatra (Hustedt, 1938b), China (Skvortzow, 1938), Denmark (Foged, 1948; 1954), and Greenland (Foged, 1973).

Ecology: Acidophilous (Foged, 1954). Current indifferent (Foged, 1954). Prefers water of low mineral content (Patrick and Reimer, 1966).

Pinnularia intermedia (Lagerst.) Cl. var. intermedia

Critical reference: Patrick and Reimer, 1966, p. 617, pl. 58, fig. 10.

Original description: Lagerstedt, 1873, p. 23, pl. 1, fig. 3. (listed as Navicula intermedia)

Transferred to Pinnularia: Cleve, 1895, p. 80.

With the exception of the valve length, the specimens examined in this study coincide well with the species description provided by Patrick and Reimer (1966). The upper limit of valve length should be increased from its present value of 42 μm to 48 μm to include the larger specimens which I have observed.

Lund (1946) considers *Pinnularia intermedia* to be the same taxon as *Pinnularia obscura* Krasske. Hustedt (1957), however, claims that the narrow valve apices and strongly convergent apical striae of *P. obscura* do not intergrade with the broadly rounded apices and more weakly convergent apical striae of *P. intermedia*. Bock (1975), in a discussion of *P. intermedia*, supports Hustedt's contention that *P. intermedia* and *P. obscura* are separate and distinct taxa. The observations which I have made concerning these two taxa support the views of Bock and Hustedt.

Previous reports from Iowa: Reported from Lake West Okoboji (Stoermer, 1963), the Des Moines River (Drum, 1964), and Dutch Creek (Fee, 1967).

Habitat distribution: Reported from ponds (Foged, 1972) and soils (Lund, 1946).

Geographic distribution: Reported from the conterminous United States (Patrick and Reimer, 1966), Alaska (Patrick and Freese, 1961), Finland (Cleve, 1891), Spitsbergen (Foged, 1964), and Greenland (Foged, 1972).

Ecology: Fresh water form (Cleve, 1895). pH indifferent (Foged, 1964; 1972). Prefers cool water which is low in mineral content (Patrick and Reimer, 1966).

<u>Pinnularia legumen</u> (Ehr.) Ehr. var. <u>legumen</u>

Critical reference: Hustedt, 1930, p. 322, fig. 587.

Original description: Ehrenberg, 1841, p. 144. (listed as <u>Navicula legumen</u>)

Transferred to <u>Pinnularia</u>: Ehrenberg, 1841 (1843), pl. 4 I, fig. 7.

The triundulate margins and weakly capitate apices described for this species (Hustedt, 1930) were observed only in the larger specimens, the smaller specimens having linear margins and rostrate apices. Many of the specimens which I observed were shorter than the 60 µm minimum length, or narrower than the 15 µm minimum breadth listed for this species. The observed range of striae number (9-13 in 10 µm) exceeds the 8-11 range described by Hustedt (1930), but falls within the range given by Werff and Huls (1974).

Some of the smaller specimens I observed could well be interpreted as <u>Pinnularia caudata</u> (Boyer) Patr. The most significant differences between <u>P. legumen</u> and <u>P. caudata</u> involve valve length and breadth, specimens of <u>P. caudata</u> being shorter and narrower than specimens of <u>P. legumen</u>. Specimens with lengths and breadths intermediate between those of <u>P. caudata</u> and <u>P. legumen</u> were frequently observed in this study. Since these two taxa thus appear to intergrade, I have chosen to assign all of the specimens to Pinnularia legumen.

Previous reports from Iowa: Reported from Pillsbury Lake bed (Hungerford, 1972) and from Dead Man's Lake (Christensen, 1976).

Habitat distribution: Reported from rivers (Hustedt, 1957), lakes (Bock, 1961; Foged, 1954; Hustedt, 1938a; Meister, 1912; Meriläinen, 1967), and bogs (Foged, 1972).

Geographic distribution: Cosmopolitan. Reported from the conterminous United States (Boyer, 1916; Patrick, 1945; Patrick and Reimer, 1966), Alaska (Patrick and Freese, 1961), Sumatra (Hustedt, 1938a), the Alps (Krasske, 1932), Switzerland (Meister, 1912), Germany (Bock, 1961; Hustedt, 1957), Denmark (Foged, 1954), Finland (Cleve, 1891; Meriläinen, 1967), and Greenland (Foged, 1972; 1973).

Ecology: Fresh water form (Boyer, 1916; Patrick and Freese, 1961). Oligohalobous (Hustedt, 1938a), listed by some as indifferent (Foged, 1954) and by others as halophobous (Hustedt, 1957). Saproxenous (Hustedt, 1957). Listed by some as pH indifferent (Foged, 1954; Hustedt, 1957), by others as acidophilous (Foged, 1972) or having a low-lying pH optimum (Cholnoky, 1968). Prefers cool water with low nutrient content (Patrick and Reimer, 1966).

Pinnularia microstauron var. brebissonii (Kütz.) Hust.

Critical reference: Hustedt, 1930, p. 321, fig. 584.

Original description: Kützing, 1844, p. 93, pl. 3, fig. 49; pl. 30, fig. 39. (listed as Navicula brebissonii)

Transferred to Pinnularia: Hustedt, 1930, p. 321, fig. 584.

Specimens were observed which were slightly broader than the 11 μm maximum breadth or slightly narrower than the 7 μm minimum breadth described by Hustedt (1930). The observed range of striae number (10-15 in 10 μm) exceeds the prescribed range of 10-13 in 10 µm, but specimens with as many as 14 or 15 striae in 10 µm have also been observed by other investigators (Hostetter and Rutherford, 1976). Although frequently described as a bilateral fascia, the central area may also be a unilateral fascia or an elliptical hyaline space. Similar variability in the structure of the central area has also been noted by Hustedt (1949) and by Barber (1977).

Variations in valve morphology similar to those observed in this study have been observed in laboratory cultures of this taxon (Hostetter and Rutherford, 1976). Using clonal cultures, Hostetter and Rutherford examined changes in valve morphology as cell size decreased. The larger cells in the culture were linear, had narrow filamentous raphes and striae which were radiate at the central area and convergent at the apices. Smaller cells were more elliptical in shape, had filiform raphes and striae which were slightly radiate at the central area and parallel or only slightly convergent at the apices. The structure of the proximal and distal raphe ends and the number of striae per 10 µm interval of valve length were little affected by changes in cell size.

Some authors regard this taxon as a separate species, _Pinnularia brebissonii_ (Kütz.) Rabh. Hustedt (1930), however, feels that this is incorrect since *P. brebissonii* is connected with *P. microstauron* by an uninterrupted series of forms. The data collected during the course of this study indicate that *P. microstauron* and *P. brebissonii* intergrade and I have therefore chosen to retain *P. brebissonii* as a variety of *P. microstauron* rather than as a separate species.

Pinnularia microstauron var. *brebissonii* fo. *diminuta* Grun. is a form which has been separated from the variety based upon its small size (length: 20-30 µm, breadth: 7-8 µm). Patrick and Reimer (1966) designate this taxon, on the basis of its smaller size and less strongly angled striae, as a variety of *P. brebissonii*. This form appears to represent the lower end of the size range of *P. microstauron* var. *brebissonii* (Plate XXIX, Figs. 14-16) and I have therefore included it within the scope of variability of variety *brebissonii*.

Previous reports from Iowa: Reported from the Des Moines River (Gudmundson, 1969; 1972; Starrett and Patrick, 1952), Lake West Okoboji (Collins, 1968; Stoermer, 1963), the Arend's Kettle Hole (Collins, 1968), Lake East Okoboji (Volker, 1963), farm ponds (Ohl, 1965), Dutch Creek (Fee, 1967), the Coralville Reservoir (Schmidt and Fee, 1967), drainage ditches in Story County (Lowe, 1970; 1972b), Clear Lake and Ventura Marsh (Begres, 1971), Brewer's Creek (Edwards and Christensen, 1972), drainage tiles near Big Spirit Lake (Edwards, 1974), Big Spirit Lake (Krohn *et al.*, 1974), and the Skunk River (Roeder, 1976).

Habitat distribution: Reported from springs (Hustedt, 1938a), creeks and streams (Dippel, 1904;

Foged, 1948; Hustedt, 1938a), rivers (Hustedt, 1957), ponds (Foged, 1972; Hare, 1978; Hustedt, 1938a), lakes (Foged, 1954; 1972; Hustedt, 1942; 1949; Patrick, 1945), bogs (Foged, 1972), and marshes (Dippel, 1904).

Geographic distribution: Cosmopolitan. Reported from the conterminous United States (Boyer, 1916; Patrick, 1945; Patrick and Reimer, 1966), Alaska (Mc Laughlin and Stone, 1976; Patrick and Freese, 1961), Java (Hustedt, 1938a), Sumatra (Hustedt, 1938a), the Philippines (Hustedt, 1942), the Belgian Congo (Hustedt, 1949), the Alps (Krasske, 1932), Switzerland (Meister, 1912), Denmark (Foged, 1954), the United Kingdom (Hare, 1978), Germany (Dippel, 1904; Hustedt, 1957), Finland (Cleve, 1891), Spitsbergen (Foged, 1964), and Greenland (Foged, 1972; 1973).

Ecology: Fresh water form (Boyer, 1916; Hustedt, 1930). Oligohalobous - indifferent (Foged, 1948; 1954). pH indifferent (Foged, 1948; 1954; 1964; 1972). Rheophilous (Foged, 1948; 1954). Prefers cool water of low mineral content (Patrick and Reimer, 1966).

Pinnularia microstauron (Ehr.) Cl. var. microstauron

Critical reference: Hustedt, 1930, p. 320, fig. 582.

Original description: Ehrenberg, 1841 (1843), p. 423, pl. 1 IV, fig. 1. (listed as Stauroptera microstauron)

Transferred to Pinnularia: Cleve, 1891, p. 28.

The specimens examined in this study differ somewhat in length, breadth, and striae number from those described by Hustedt (1930). Specimens which were shorter than the 25 µm minimum length or longer than the 80 µm maximum length were observed. Although most specimens fell within the prescribed breadth range of 7-11 µm, some were found to have breadths as great as 18 µm. Striae numbers ranged from 9-14 in 10 µm, an extension of the 10-13 range commonly reported for this species.

Hustedt (1930) describes this as an extraordinarily variable taxon. Lund (1946) observed soil-dwelling forms of this species which had valves as short as 14 µm, as narrow as 5 µm, and with striae numbers as low as 13 or as high as 20 in 10 µm. In addition, Lund (1946) observed a complete series of gradations connecting _Pinnularia microstauron_ with _P. microstauron_ var. _brebissonii_ (Kütz.) Hust. and with _P. microstauron_ var. _brebissonii_ fo. _diminuta_ Grun. The shape of the valve apices appears to be the only factor separating _P. microstauron_ from _P. microstauron_ var. _brebissonii_, _P. microstauron_ having bluntly rounded or subrostrate apices, variety _brebissonii_ having cuneate apices.

Previous reports from Iowa: Reported from a soil sample collected near Iowa City (Hayek and Hulbary, 1956), South Falls near Pella (Stoermer, 1962), Lake West Okoboji (Stoermer, 1963), the Des Moines River (Drum, 1964; Gudmundson, 1969; 1972), a soil sample from Cayler Prairie (Reimer, 1970), Pillsbury and Sylvan Lake beds (Hungerford, 1972), and Dead Man's Lake (Christensen, 1976).

Habitat distribution: Reported from an artesian well (Boyer, 1916), springs (Hustedt, 1938a), creeks and streams (Foged, 1948; Hustedt, 1938a), rivers (Hustedt, 1957), waterfalls (Hustedt, 1938a), ponds (Foged, 1972; Hustedt, 1942), lakes (Foged, 1954; 1972; Hustedt, 1935; 1938a; 1942; 1949; Meriläinen, 1967), heaths (Hustedt, 1938a), bogs (Foged, 1972; Skvortzow, 1938), and soils (Lund, 1946).

Geographic distribution: Cosmopolitan. Reported from the conterminous United States (Boyer, 1916; Patrick and Reimer, 1966), Alaska (Patrick and Freese, 1961), the Hawaiian Islands (Hustedt, 1942), Java (Hustedt, 1938a), Sumatra (Hustedt, 1935; 1938a), the Philippines (Hustedt, 1942), China (Skvortzow, 1938), the Belgian Congo (Hustedt, 1949), the Alps (Krasske, 1932), Switzerland (Meister, 1912), Germany (Hustedt, 1957), Denmark (Foged, 1948; 1954), Finland (Cleve, 1891; Meriläinen, 1967), Spitsbergen (Foged, 1964), and Greenland (Foged, 1972; 1973).

Ecology: Fresh water form (Hustedt, 1930). Oligohalobous (Hustedt, 1938a) or oligohalobous - indifferent (Foged, 1948; 1954; Hustedt, 1957). Oligosaprobous (Hustedt, 1957). Listed by some as acidophilous (Foged, 1948; 1954), by others as pH indifferent (Foged, 1964; 1972; Hustedt, 1957), or with a pH optimum just above 7 (Cholnoky, 1968). Current indifferent (Foged, 1948; 1954). Seems to prefer oligotrophic waters which are slightly acid (Patrick and Reimer, 1966).

Pinnularia obscura Krasske var. *obscura*

Critical reference: Patrick and Reimer, 1966, p. 617, pl. 58, fig. 9.

Original description: Krasske, 1932, p. 117, pl. 3, fig. 22.

The specimens which I observed differ from those described by Patrick and Reimer (1966) in length, breadth, and striae number. Some of the specimens were considerably longer than the prescribed 22 μm maximum length. The observed breadth range of 4-7 μm represents an extension of the 3-5 μm range given in the description. Striae numbers differed markedly from the prescribed 13-15 in 10 μm, some specimens having as few as 9 striae in 10 μm.

In a study of the diatoms of the Pocono Plateau and adjacent regions, Patrick (1945) cited the striae number given in Krasske's (1932) original description as being 10 in 10 µm. The figure given by Patrick is erroneous, the actual figure given by Krasske being 15 striae in 10 µm. The striae number of the specimens which Patrick (1945) reported from the Pocono Plateau falls within the range observed in this study, but does not fall within the range given by Patrick and Reimer (1966).

Previous reports from Iowa: Reported from the Des Moines River (Drum, 1964), farm ponds (Ohl, 1965), Dutch Creek (Fee, 1967), and Lake West Okoboji (Collins, 1968).

Habitat distribution: Reported from rivers (Hustedt, 1957), ponds (Foged, 1972), lakes (Foged, 1954), and mosses (Patrick and Reimer, 1966).

Geographic distribution: Reported from the conterminous United States (Patrick, 1945; Patrick and Reimer, 1966), Alaska (Patrick and Freese, 1961), the Alps (Krasske, 1932), Germany (Hustedt, 1957), Denmark (Foged, 1954), Spitsbergen (Foged, 1964), and Greenland (Foged, 1972; 1973).

Ecology: Fresh water form (Patrick and Reimer, 1966). Oligohalobous - indifferent (Hustedt, 1957). Oligosaprobous (Hustedt, 1957). Listed by some as pH indifferent (Foged, 1964; 1972; Hustedt, 1957), but by Cholnoky (1968) as having a pH optimum below 6.

Pinnularia stomatophora (Grun.) Cl. var. *stomatophora*

Critical reference: Patrick and Reimer, 1966, pp. 609-610, pl. 57, fig. 5.

Original description: Grunow, 1876, *in* Schmidt *et al*., 1874-1959, pl. 44, figs. 27-29. (listed as *Navicula stomatophora*)

Transferred to *Pinnularia*: Cleve, 1891, p. 27.

Patrick and Reimer (1966) describe valves of this taxon as 59-110 µm long and 9-11 µm wide with 12-14 striae in

10 μm. The observed ranges of length (41-105 μm), breadth (6-12 μm), and striae number (11-15 in 10 μm) represent extensions of the ranges given by Patrick and Reimer. The central area is frequently a bilateral fascia, as described by Patrick and Reimer, but it may also be a unilateral fascia or an elliptical hyaline space. Markings in the central area may or may not be present. When present, the markings are lunate, or consist of a series of irregular spots. The raphe, described as filamentous by Patrick and Reimer (1966), frequently appears to be slightly undulate or undulate.

Descriptions of Pinnularia stomatophora state that specimens of this taxon possess a lunate marking on each side of the central nodule and also possess striae which are radiate at the central area and convergent at the apices. In 1934, Hustedt established the species Pinnularia substomatophora to encompass specimens which were similar to P. stomatophora, but which had more strongly radiate and convergent striae and lacked markings in the central area. Hustedt later observed, after having examined specimens from various habitats, that the markings in the central area and the divergence of the striae were highly variable characteristics (Hustedt, 1938b). Smaller cells were found to exhibit more abrupt changes in striae direction than did larger cells. Markings in the central area were sometimes found to be only weakly developed or, in some cases, to be completely absent. Occasionally, the markings were observed on one valve of a frustule, but were absent on the other. These observations led Hustedt to conclude that _P. substomatophora_ merely represented part of the group of forms comprising _P. stomatophora_. Consequently, in 1938, Hustedt retracted the name _P. substomatophora_. The species name _Pinnularia substomatophora_ Hust. is, however, still frequently encountered in the present day literature.

Previous reports from Iowa: Reported from Excelsior Fen (Shobe _et al._, 1963), Lake West Okoboji (Collins, 1968; Stoermer, 1963), the Arend's Kettle Hole (Collins, 1968), and Dead Man's Lake (Christensen, 1976).

Habitat distribution: Reported from rivers (Hustedt, 1957), ponds (Krasske, 1932), lakes (Foged, 1954; 1972; Hustedt, 1942; 1949; Meriläinen, 1967), swamps (Hustedt, 1942), and moss clumps (Krasske, 1932).

Geographic distribution: Cosmopolitan. Reported from the conterminous United States (Boyer, 1916; Patrick, 1945; Patrick and Reimer, 1966), Java (Hustedt, 1938b; 1942), Sumatra (Hustedt, 1938b), the Philippines (Hustedt, 1942), the Belgian Congo (Hustedt, 1949), the Alps (Krasske, 1932), Germany (Hustedt, 1957), Denmark (Foged, 1954), Finland (Cleve, 1891; Meriläinen, 1967), Spitsbergen (Foged, 1964), and Greenland (Foged, 1972; 1973).

Ecology: Fresh water form (Boyer, 1916; Cleve, 1895). Listed by some as oligohalobous (Hustedt, 1938b) or oligohalobous - indifferent (Foged, 1954), but by others as halophobous (Hustedt, 1957). Saproxenous (Hustedt, 1957). Listed by some as acidophilous (Foged, 1954; 1972) or with a pH optimum between 5 and 5.5 (Cholnoky, 1968), but by others as pH indifferent (Foged, 1964; Hustedt, 1957). Limnophilous (Foged, 1954). Prefers cool water which is low in minerals (Patrick and Reimer, 1966).

Pinnularia species #2

The taxonomic position of this entity is highly uncertain. The specimens resemble *Pinnularia abaujensis* var. *subundulata* in size, shape, striae number, striae angle, and structure of the apical raphe fissures. They differ, however, from *P. abaujensis* var. *subundulata* in having narrower, more filiform raphes and axial areas which are often extremely narrow. Longitudinal bands, which were never observed in *P. abaujensis* var. *subundulata*, were occasionally visible near the tips of the striae bordering the central area.

Pinnularia species #3

Specimens of this taxon resemble *Pinnularia microstauron* in size, striae number, striae angle, raphe type, and structure of the apical raphe fissures. The principal difference between these specimens and those of *P. microstauron* is the shape of the valve apices, many of the specimens exhibiting capitate or subcapitate apices rather than the subrostrate or bluntly rounded apices typical of *P. microstauron*.

Maiores

Pinnularia maior (Kütz.) Rabh. var. *maior*

Critical reference: Patrick and Reimer, 1966, p. 629, pl. 61, fig. 4.

Original description: Kützing, 1833, p. 547, pl. 14, fig. 25. (listed as *Frustulia* maior)

Transferred to Navicula: Kützing, 1844, p. 97, pl. 4, figs. 19 and 20.

Transferred to Pinnularia: Rabenhorst, 1853, p. 42, pl. 6, fig. 5; pl. 10 supp., fig. 4.

The ranges of length, breadth, and striae number observed in this study represent extensions of the ranges given by Patrick and Reimer (1966). The maximum length (276 μm) observed in this study is considerably greater than the 200 μm maximum length given by Patrick and Reimer. However, specimens as long as 280 μm have been reported in the literature (Meister, 1912). Some of the specimens encountered were as narrow as 22 μm. This falls outside of the breadth range given by Patrick and Reimer, but is within the range reported by Dippel (1904). Although typically described as occupying one-fourth to one-fifth of the valve breadth, the axial area may occasionally occupy as much as one-third of the valve breadth (Hare, 1978). The broad, filamentous raphe may sometimes exhibit a very slight tendency toward complexity.

Previous reports from Iowa: Reported from fossil diatomaceous earth from Muscatine County (Myers, 1898b), North Twin Lake (Kutkuhn, 1958), Lake West Okoboji (Stoermer, 1963), farm ponds (Ohl, 1965), Dutch Creek (Fee, 1967), the West Branch of Big Cedar Creek (Hungerford, 1971), and Dead Man's Lake (Christensen, 1976).

Habitat distribution: Reported from creeks and streams (Dippel, 1904; Foged, 1948), rivers (Hustedt, 1957), ponds (Foged, 1972; Hare, 1978), and lakes (Foged, 1954; 1972; Hare, 1978; Hustedt, 1938b; 1942; Meriläinen, 1967; Patrick, 1945).

Geographic distribution: Cosmopolitan. Reported from the conterminous United States (Boyer, 1916; Patrick, 1945; Patrick and Reimer, 1966), the Hawaiian Islands (Hustedt, 1942), Bali (Hustedt, 1938b), Sumatra (Hustedt, 1938b), the Sunda Islands (Hustedt, 1938b), the Philippines (Hustedt, 1942), the Belgian Congo (Hustedt, 1949), the Alps (Krasske, 1932), Germany (Dippel, 1904; Hustedt, 1957), Denmark (Foged, 1948; 1954), the United Kingdom (Hare, 1978), Finland (Cleve, 1891; Meriläinen, 1967), Spitsbergen (Foged, 1964), and Greenland (Foged, 1972; 1973).

Ecology: Fresh water form (Boyer, 1916; Cleve, 1895). Oligohalobous (Hustedt, 1938b) or oligohalobous - indifferent (Foged, 1948; 1954; Hustedt, 1957). Oligosaprobous (Hustedt, 1957). Listed by some as acidophilous (Foged, 1948; 1954), or with a pH optimum around 6 (Cholnoky, 1968), but by others as pH indifferent (Foged, 1964; 1972; Hustedt, 1957). Limnobiontic (Foged, 1948; 1954). Widely distributed in water which has a fairly low mineral content (Patrick and Reimer, 1966).

Pinnularia maior var. *pulchella* Boyer

Critical reference: Patrick and Reimer, 1966, pp. 629-630, pl. 61, fig. 5.

Original description: Boyer, 1916, p. 102, pl. 28, fig. 2.

Patrick and Reimer (1966) give the minimum length of this taxon as being 220 µm. An extension of the length range down to 165 µm, as has been suggested by Christensen (1976), would include the smaller specimens observed in this study. Similarly, the valve breadth of 40 µm given in the description should be adjusted to include the narrower individuals which I have observed. In some specimens, the axial area was found to occupy one-fourth of the valve breadth, as described by Patrick and Reimer (1966), but in others it was found to be somewhat broader, occupying up to one-third of the valve breadth. The granular appearance of the axial area is not mentioned by Patrick and Reimer, but has been observed by Christensen (1976). The observed range of striae numbers (7-8 in 10 μm) represents a slight expansion of the 6-7 range given by Patrick and Reimer.

Previous reports from Iowa: Reported from Dead Man's Lake (Christensen, 1976).

Habitat distribution: Reported from ponds (Boyer, 1916; Patrick and Reimer, 1966) and lakes (Patrick and Reimer, 1966).

Geographic distribution: Reported from the conterminous United States (Boyer, 1916; Patrick and Reimer, 1966).

Ecology: Inhabits slightly acid ponds or lakes with water of very low mineral content (Patrick and Reimer, 1966).

Pinnularia maior var. *transversa* (A.S.) Cl.

Critical reference: Patrick and Reimer, 1966, p. 630, pl. 61, fig. 6.

Original description: Schmidt, 1876, *in* Schmidt *et al.*, 1874-1959, pl. 43, figs. 5 and 6. (listed as *Navicula transversa*)

Transferred to *Pinnularia maior*: Cleve, 1891, p. 24.

The lower limit of the length range should be extended downward from the value of 170 μm given by Patrick and Reimer (1966) to 134 μm to encompass the shorter individuals found in this study. Similarly, the breadth range of

17-20 µm given by Patrick and Reimer should be expanded to 16-23 µm to include the narrower and broader specimens which I have observed. Although typically occupying one-third of the valve breadth, the axial area may, in some cases, be as narrow as one-fifth of the valve breadth.

Previous reports from Iowa: Reported from farm ponds (Ohl, 1965) and from Dead Man's Lake (Christensen, 1976).

Habitat distribution: Reported from lakes (Patrick, 1945).

Geographic distribution: Reported from the conterminous United States (Patrick, 1945; Patrick and Reimer, 1966) and from Finland (Cleve, 1891).

Ecology: Fresh water form (Cleve, 1895). Seems to prefer cool water which is low in mineral content (Patrick and Reimer, 1966).

Complexae

Pinnularia ruttneri Hust. var. *ruttneri*

Critical reference: Hustedt, 1935, p. 162, pl. II, fig. 16.

Original description: Hustedt, 1934, *in* Schmidt *et al.*, 1874-1959, pl. 390, figs. 6 and 7.

The specimens which I observed differed from those described by Hustedt (1935) in several respects. Some of the specimens were shorter than the prescribed 150 µm minimum length. The observed breadth range (14-29 µm) was considerably broader than the 18-23 µm range given by Hustedt. Christensen (1976), in his study of Dead Man's

Lake, also noted specimens which were too short or too narrow to fit the established ranges. Although most specimens possessed the prescribed striae number (7 in 10 µm), striae numbers as low as 6 and as high as 9 were observed. The axial area, which typically occupies one-third of the valve breadth, was occasionally found to be somewhat narrower, occupying one-fourth or one-fifth of the valve breadth. The breadth of the longitudinal bands varied from one-third to one-sixth of the striae length.

The taxonomically significant characteristics in this species are the broad axial area, the narrow longitudinal bands, and the highly complex raphe. Specimens of *Pinnularia ruttneri* having narrower axial areas and broader longitudinal bands than those typical of the species may be confused with specimens of *Pinnularia viridis*. The apparent intergradation of these two species has also been noted by Cholnoky (1968) and by Bock (1961).

Previous reports from Iowa: Reported from Cayler Prairie (Reimer, 1970), Clear Lake (Begres, 1971), and Dead Man's Lake (Christensen, 1976).

Habitat distribution: Reported from lakes (Hustedt, 1935; 1942).

Geographic distribution: Reported from the conterminous United States (Patrick and Reimer, 1966), Sumatra (Hustedt, 1935), and the Philippines (Hustedt, 1942).

Ecology: Fresh water form (Patrick and Reimer, 1966). pH optimum below 6 (Cholnoky, 1968). Inhabits acid water which is low in mineral content (Patrick and Reimer, 1966).

<u>Pinnularia streptoraphe</u> Cl. var. <u>streptoraphe</u>

Critical reference: Patrick and Reimer, 1966, p. 639, pl. 64, fig. 4.

Original description: Cleve, 1891, p. 23.

The specimens observed in this study fell within the range of variability described by Patrick and Reimer (1966). This taxon has a more broadly linear shape and a lower striae number (4-5 in 10 μm) than do <u>Pinnularia viridis</u> and <u>Pinnularia ruttneri</u>.

<u>Previous reports from Iowa</u>: Reported from the Arend's Kettle Hole (Collins, 1968), a drainage ditch in Story County (Lowe, 1970; 1972a; 1972b), Pillsbury Lake bed (Hungerford, 1972), and Dead Man's Lake (Christensen, 1976).

<u>Habitat distribution</u>: Reported from rivers (Hustedt, 1957), ponds (Patrick and Reimer, 1966), lakes (Foged, 1972; Meister, 1912; Patrick, 1945; Patrick and Reimer, 1966), and bogs (Patrick and Reimer, 1966; Skvortzow, 1938).

<u>Geographic distribution</u>: Reported from the conterminous United States (Patrick, 1945; Patrick and Reimer, 1966), Alaska (Patrick and Freese, 1961), China (Skvortzow, 1938), Switzerland (Meister, 1912), Germany (Hustedt, 1957), Finland (Cleve, 1891), and Greenland (Foged, 1972; 1973).

<u>Ecology</u>: Fresh water form (Cleve, 1895). Oligohalobous - halophobous (Hustedt, 1957). Saproxenous (Hustedt, 1957). Listed by some as acidophilous (Hustedt, 1957) or with a very low-lying pH optimum (Cholnoky, 1968), but by others as pH indifferent (Foged, 1972). Prefers cold water (Patrick, 1948). Seems to prefer acid water which is low in mineral content (Patrick and Reimer, 1966).

<u>*Pinnularia viridis* var. *intermedia* Cl.</u>

Critical reference: Hustedt, 1930, p. 335.

Original description: Cleve, 1891, p. 22.

Typical specimens of this taxon are, according to Hustedt's (1930) description, 70-110 µm long, 14-15 µm wide, and have 8-9 striae in 10 µm. The axial area occupies about one-fourth of the valve breadth and the longitudinal bands are narrow.

The specimens examined in this study exhibited an extensive range of variability. The observed ranges of valve length (64-131 µm) and valve breadth (11-18 µm) exceed those given in the description. The striae number, while typically 8-9 in 10 µm, varied from as low as 7 to as high as 10. Although frequently one-fourth of the valve breadth, axial area breadths of one-third of the valve breadth were not uncommon. Longitudinal bands varied in breadth from one-fifth of the striae length to one-half of the striae length.

Similar forms of variation have also been observed by Bock (1961). His specimens ranged from 80 to 131 µm in length, 13 to 17 µm in breadth, and had 7 to 8 striae in 10 µm. In some specimens, the raphe was only slightly complex, in others, it was highly complex. The breadth of the axial area was found to be quite variable. In one case, Bock found an intact frustule in which the axial area occupied one-fourth of the valve breadth on one valve, and one-sixth to one-seventh of the valve breadth on the other. The breadth of the longitudinal bands ranged from one-third to one-half of the striae length.

This form is separated from the species on the basis of its broad axial area, narrow longitudinal bands, and striae number. The observations presented above, particularly those relating to the axial area and longitudinal bands, indicate that this variety intergrades extensively with the nominate variety.

Previous reports from Iowa: Reported from Clear Lake and Ventura Marsh (Begres, 1971) and Dead Man's Lake (Christensen, 1976).

Habitat distribution: Reported from Alaska (Mc Laughlin and Stone, 1976; Patrick and Freese, 1961), Switzerland (Meister, 1912), Germany (Bock, 1961), Finland (Cleve, 1891), and Greenland (Foged, 1973).

Ecology: Fresh water form (Cleve, 1895).

Pinnularia viridis (Nitz.) Ehr. var. viridis

Critical reference: Hustedt, 1930, p. 334, fig. 617a.

Original description: Nitzsch, 1817, p. 97, pl. 6, figs. 1-3. (listed as Bacillaria viridis)

Transferred to Pinnularia: Ehrenberg, 1841 (1843), p. 385, pl. 1 IV, fig. 3; pl. 2 I, fig. 22; pl. 2 V, fig. 2; pl. 3 I, figs. 1 and 2.

The observed length and breadth ranges represent extensions of the ranges presented by Hustedt (1930). The striae number, raphe type, axial area, and longitudinal bands are all quite variable. The striae numbers of most specimens fell within the 6 to 9 range, but occasionally striae numbers of 10 or 11 were observed. Some specimens, particularly those near the lower limit of the length range, possessed undulate or filamentous raphes rather than the complex type typical of this species. In some cases, the axial area was quite broad (one-third of the valve breadth), in others it was quite narrow (one-seventh of the valve breadth). The longitudinal bands were broad in some specimens and narrow in others. Bock (1961) has also found substantial variability in the structure of the raphe, the breadth of the axial area, and the breadth of the longitudinal bands.

This taxon is highly variable and appears to be closely related to a number of other taxa. Large specimens with slightly complex raphes resemble Pinnularia maior (Boyer, 1916). Specimens such as these led Hustedt (1938b) to conclude that no sharp demarcation exists between the Maiores and Complexae. Large specimens with highly complex raphes, broad axial areas, and narrow longitudinal bands approach Pinnularia ruttneri (Bock, 1961). Smaller specimens with broad axial areas and narrow longitudinal bands intergrade with _Pinnularia viridis_ var. _intermedia_. No specimens were observed which could be definitely identified as _Pinnularia viridis_ var. _commutata_ (Grun.) Cl. or _P. viridis_ var. _minor_ Cl. and I can, therefore, make no judgment about their relationship to the nominate variety.

Previous reports from Iowa: Reported from the Des Moines River (Drum, 1964; Ehrenberg, 1856; Starrett and Patrick, 1952), Excelsior Fen (Shobe _et al_., 1963), Lake West Okoboji (Stoermer, 1963), Lake East Okoboji (Volker, 1963), farm ponds (Ohl, 1965), Dutch Creek (Fee, 1967), the Arend's Kettle Hole (Collins, 1968), drainage ditches in Story County (Lowe, 1970; 1972b), Cayler Prairie (Reimer, 1970), Clear Lake and Ventura Marsh (Begres, 1971), Pillsbury and Sylvan Lake beds (Hungerford, 1972), drainage tiles near Big Spirit Lake (Edwards, 1974), Big Spirit Lake (Krohn _et al_., 1974), Dead Man's Lake (Christensen, 1976), and the Skunk River (Beckert, 1977; Roeder, 1976).

Habitat distribution: Reported from springs (Hustedt, 1935; 1938b), creeks and streams (Foged, 1948; Hustedt, 1935), rivers (Hustedt, 1942; 1957), ponds (Foged, 1972; Hare, 1978), lakes (Foged, 1954; 1972; Hare, 1978; Hustedt, 1935; 1942; 1949; Merilӓinen, 1967; Patrick, 1945), swamps (Hustedt, 1935), and soils (Lund, 1946).

Geographic distribution: Cosmopolitan. Reported from the conterminous United States (Boyer, 1916; Patrick, 1945; Patrick and Reimer, 1966), Alaska (Mc Laughlin and Stone, 1976; Patrick and Freese, 1961), the Hawaiian Islands (Hustedt, 1942), Java (Hustedt, 1938b; 1942), Bali (Hustedt, 1938b), Sumatra (Hustedt, 1935; 1938b), the Philippines (Hustedt, 1942), the Belgian Congo (Hustedt, 1949), the Alps (Krasske, 1932), Switzerland (Meister, 1912), Germany (Dippel, 1904; Hustedt, 1957), the United Kingdom (Hare, 1978), Denmark (Foged, 1948; 1954), Finland (Cleve, 1891; Merilӓinen, 1967), Spitsbergen (Foged, 1964), and Greenland (Foged, 1972; 1973).

Ecology: Fresh water form (Boyer, 1916; Cleve, 1895; Hustedt, 1930). Oligohalobous (Hustedt, 1938b) or oligohalobous - indifferent (Foged, 1948; 1954; Hustedt, 1957). Oligosaprobous (Hustedt, 1957). Listed by some as pH indifferent (Foged, 1948; 1954; 1964; 1972; Hustedt, 1957), but by Cholnoky (1968) as having a pH optimum between 5.6 and 6. Current indifferent (Foged, 1948; 1954). Found in water with higher mineral content than tolerated by many Pinnularia species (Patrick and Reimer, 1966).

Barber (1977) has noted that, within a given Pinnularia species, there are a number of valve characteristics which frequently exhibit significant variability. Variation in valve outline is not uncommon. The two valves of a given frustule may differ in axial area breadth and central area size. The striae may be interrupted or continuous on one or both sides of each valve. Two valves of the same frustule may show different degrees of radiation and convergence of the striae. Variations such as these are often not depicted in the species descriptions and have led, in Barber's opinion, to unnecessary additions to the taxonomy of this genus.

In a study of Pinnularia acoricola Hust., Carter (1972) observed variability in valve size and shape, size and shape of the axial area, curvature of the raphe, and degree and direction of radiation of the striae. So great was the variation, that Carter hesitated to place any reliability on the specificity of these characteristics. Carter did, however, find the striae number to be a reasonably stable character.

Most of the species observed in this study showed considerable variation in valve size and shape, size and shape of the axial and central areas, and degree and direction of radiation of the striae. The striae number and raphe structure, particularly the structure of the apical raphe fissures, were found to be, in most cases, reasonably stable.

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APPENDIX A:

KEY TO THE SPECIES OF <u>PINNULARIA</u> ENCOUNTERED IN THIS STUDY

1a.	Raphe complex.	2.
1b.	Raphe filiform, filamentous, or undulate.	6.
2a.	Striae coarse, 3-5 in 10 µm.	3.
2b.	Striae finer, 6-11 in 10 µm.	4.
3a.	Striae distant from each other. Longitudinal bands absent. _P_. _lata_ var. _lata_ (Fig. 9)	
3b.	Striae close together. Longitudinal bands present. _P_. _streptoraphe_ var. _streptoraphe_ (Fig. 5)	
4a.	Axial area broad, one-fourth to one-third of the valve breadth.	5.
4b.	Axial area narrow, one-fifth or less of the valve breadth. _P_. _viridis_ var. _viridis_ (Fig. 6)	
5a.	Valves large, greater than 140 µm in length. _P_. _ruttneri_ var. _ruttneri_ (Fig. 3)	
5b.	Valves small, less than 130 µm in length. _P_. _viridis_ var. _intermedia_ (Fig. 7)	
6a.	Valves large, greater than 130 µm in length.	7.
6b.	Valves less than 130 µm in length.	9.
7a.	Valves broad, 22-38 µm in breadth. Striae, 6-8 in 10 µm.	8.
7b.	Valves slender, 16-23 µm in breadth. Striae, 8-9 in 10 µm. _P_. _maior_ var. _transversa_ (Fig. 4)	
8a.	Valves distinctly inflated at the central area. Longitudinal bands occurring only at the tips of the striae. _P_. _maior_ var. _pulchella_ (Fig. 1)	
8b.	Valves linear or slightly inflated at the central area. Longitudinal bands one-fifth to two-thirds of the length of the striae. _P_. _maior_ var. _maior_ (Fig. 2)	
9a.	Raphe slightly undulate or undulate.	10.
9b.	Raphe filiform or filamentous.	13.

10a. Valve apices subcapitate or rostrate.
Apical raphe fissures intermediate between "comma" and "bayonet" shaped.
P. legumen var. legumen (Fig. 10)

10b. Valve apices not subcapitate or rostrate and/or apical raphe fissures not intermediate between "comma" and "bayonet" shaped. 11.

11a. Apical raphe fissures "bayonet" shaped.
P. stomatophora var. stomatophora (Fig. 13)

11b. Apical raphe fissures not "bayonet" shaped. 12.

12a. Valves greater than 65 μm in length.
P. brevicostata var. brevicostata (Fig. 8)

12b. Valves less than 55 μm in length.
P. intermedia var. intermedia (Fig. 23)

13a. Axial area granular. One apical raphe fissure "Y" shaped, the other "comma" shaped.
P. acrosphaeria var. acrosphaeria (Fig. 14)

13b. Axial area not granular and/or apical raphe fissures not "Y" and "comma" shaped. 14.

14a. Raphe bordered by two dark lines.
P. nodosa var. nodosa (Fig. 19)

14b. Raphe not bordered by two dark lines. 15.

15a. Valve apices capitate or subcapitate, much narrower than the main body of the valve. 16.

15b. Valve apices not capitate or subcapitate, or if capitate or subcapitate, not much narrower than the main body of the valve. 19.

16a. Valve breadth at least 9 μm. 17.

16b. Valve breadth less than 8 μm. 18.

17a. Axial area narrow throughout most of the valve length, becoming broad only at the central area.
P. biceps var. biceps (Fig. 18)

17b. Axial area broad throughout most of the valve length, becoming narrow only at the valve apices.
P. braunii var. braunii (Fig. 16)

18a. Valve margins undulate.
P. *mesolepta* var. *mesolepta* (Fig. 27)

18b. Valve margins linear or slightly concave.
P. *interrupta* var. *interrupta* (Fig. 25)

19a. Striae distant from each other, 3-7 in 10 μm.
P. *borealis* var. *borealis* (Fig. 28)

19b. Striae close together. 20.

20a. Valves lanceolate.
P. *abaujensis* var. *abaujensis* (Fig. 11)

20b. Valves not lanceolate. 21.

21a. Valve apices cuneate. 22.

21b. Valve apices not cuneate. 23.

22a. Apical raphe fissures "bayonet" shaped or intermediate between "comma" and "bayonet" shaped.
P. *microstauron* var. *brebissonii* (Fig. 20)

22b. Apical raphe fissures "comma" shaped.
P. *leptosoma* var. *leptosoma* (Fig. 22)

23a. Apical raphe fissures "bayonet" shaped or intermediate between "comma" and "bayonet" shaped. 24.

23b. Apical raphe fissures not "bayonet" shaped or intermediate between "comma" and "bayonet" shaped. 25.

24a. Valve apices rostrate, subrostrate, or bluntly rounded.
P. *microstauron* var. *microstauron* (Fig. 12)

24b. Valve apices subcapitate.
P. species #3 (Fig. 15)

25a. Striae at the valve apices *very* strongly convergent.
P. *obscura* var. *obscura* (Fig. 26)

25b. Striae at the valve apices not extremely convergent. 26.

26a. Raphe filiform. 28.

26b. Raphe filamentous. 27.

27a. Valves slender, slightly undulate.
P. abaujensis var. *subundulata* (Fig. 17)

27b. Valves broad, linear.
P. species #2 (Fig. 21)

28a. Striae fine, 15-18 in 10 μm. Valve apices broad, subcapitate.
P. species #1 (Fig. 30)

28b. Striae number not within the range of 15-18 in 10 μm and/or valve apices not broad and subcapitate. 29.

29a. Valves biundulate or triundulate.
P. mesolepta fo. *angusta* (Fig. 24)

29b. Valves not biundulate or triundulate. 30.

30a. Valves very slender, generally 4-6 μm in breadth.
P. subcapitata var. *subcapitata* (Fig. 29)

30b. Valves broader, generally 7-9 μm in breadth.
P. species #2 (Fig. 21)

Plate XLVII

Key to the species of _Pinnularia_ encountered in this study. X1000.

Fig. 1. _Pinnularia maior_ var. _pulchella_ Boyer.
vl: 202 μm, vb: 34 μm, s/10 μm: 7.

Fig. 2. _Pinnularia maior_ (Kütz.) Rabh. var. _maior_.
vl: 193 μm, vb: 26 μm, s/10 μm: 7-8.

Fig. 3. _Pinnularia ruttneri_ Hust. var. _ruttneri_.
vl: 180 μm, vb: 24 μm, s/10 μm: 7.

Fig. 4. _Pinnularia maior_ var. _transversa_ (A.S.) Cl.
vl: 167 μm, vb: 18 μm, s/10 μm: 8-9.

vl = valve length; vb = valve breadth; s/10 μm = number of striae per 10 μm interval

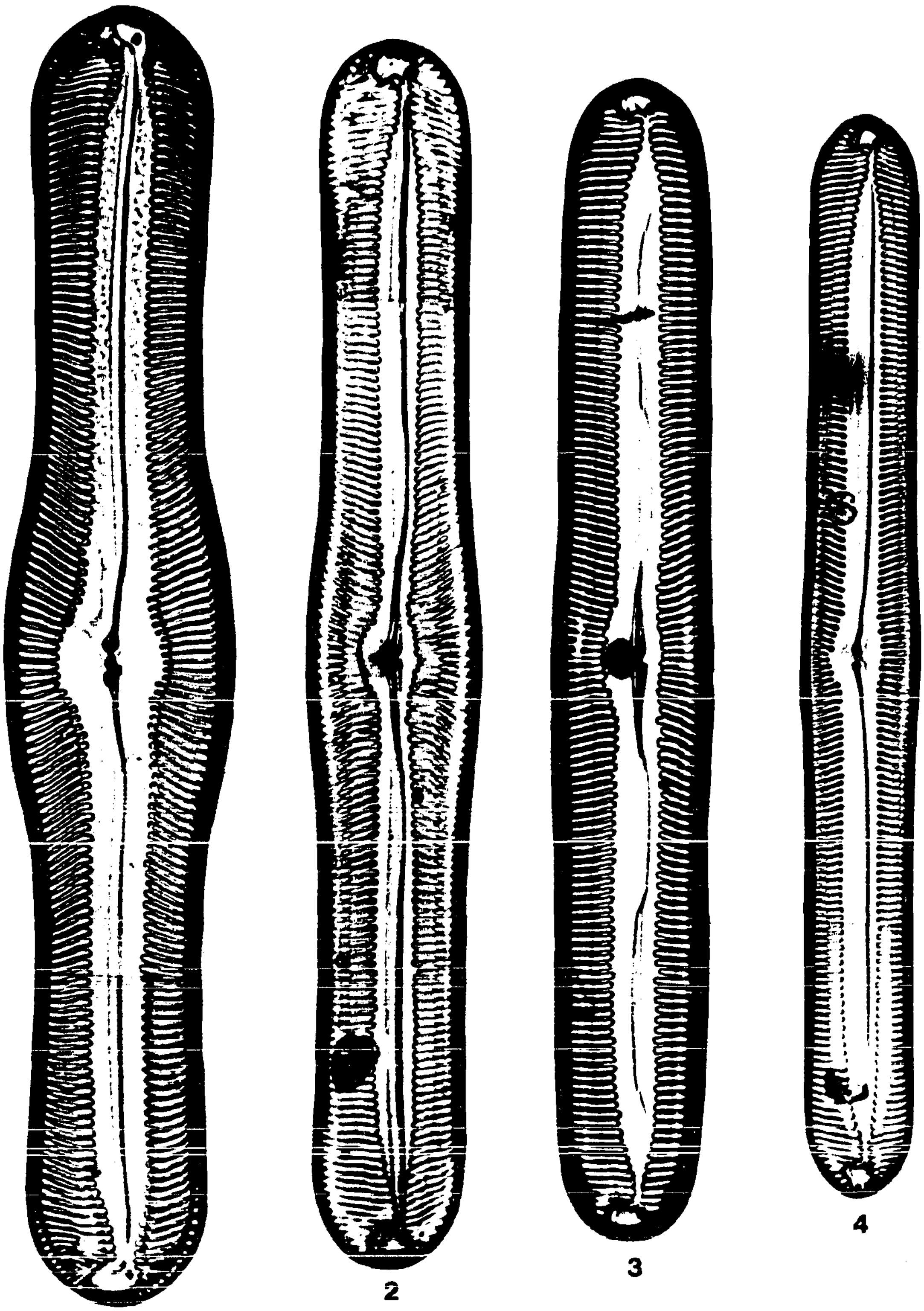

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Plate XLVII (continued)

Key to the species of Pinnularia encountered in this study. X1000.

Fig. 5. Pinnularia streptoraphe Cl. var. streptoraphe.
vl: 164 µm, vb: 26 µm, s/10 µm: 5.

Fig. 6. Pinnularia viridis (Nitz.) Ehr. var. viridis.
vl: 120 µm, vb: 20 µm, s/10 µm: 8.

Fig. 7. Pinnularia viridis var. intermedia Cl.
vl: 105 µm, vb: 15 µm, s/10 µm: 8.

Fig. 8. Pinnularia brevicostata Cl. var. brevicostata.
vl: 93 µm, vb: 13 µm, s/10 µm: 9.

Fig. 9. Pinnularia lata (Bréb.) Rabh. var. lata.
vl: 89 µm, vb: 23 µm, s/10 µm: 3.

Fig. 10. Pinnularia legumen (Ehr.) Ehr. var. legumen.
vl: 75 µm, vb: 16 µm, s/10 µm: 9.

Fig. 11. Pinnularia abaujensis (Pant.) Ross var. abaujensis.
vl: 71 µm, vb: 11 µm, s/10 µm: 11-12.

Fig. 12. Pinnularia microstauron (Ehr.) Cl. var. microstauron.
vl: 70 µm, vb: 13 µm, s/10 µm: 11.

Fig. 13. Pinnularia stomatophora (Grun.) Cl. var. stomatophora.
vl: 67 µm, vb: 9 µm, s/10 µm: 13.

Fig. 14. Pinnularia acrosphaeria W. Sm. var. acrosphaeria.
vl: 65 µm, vb: 9 µm, s/10 µm: 11.

vl = valve length; vb = valve breadth; s/10 µm = number of striae per 10 µm interval

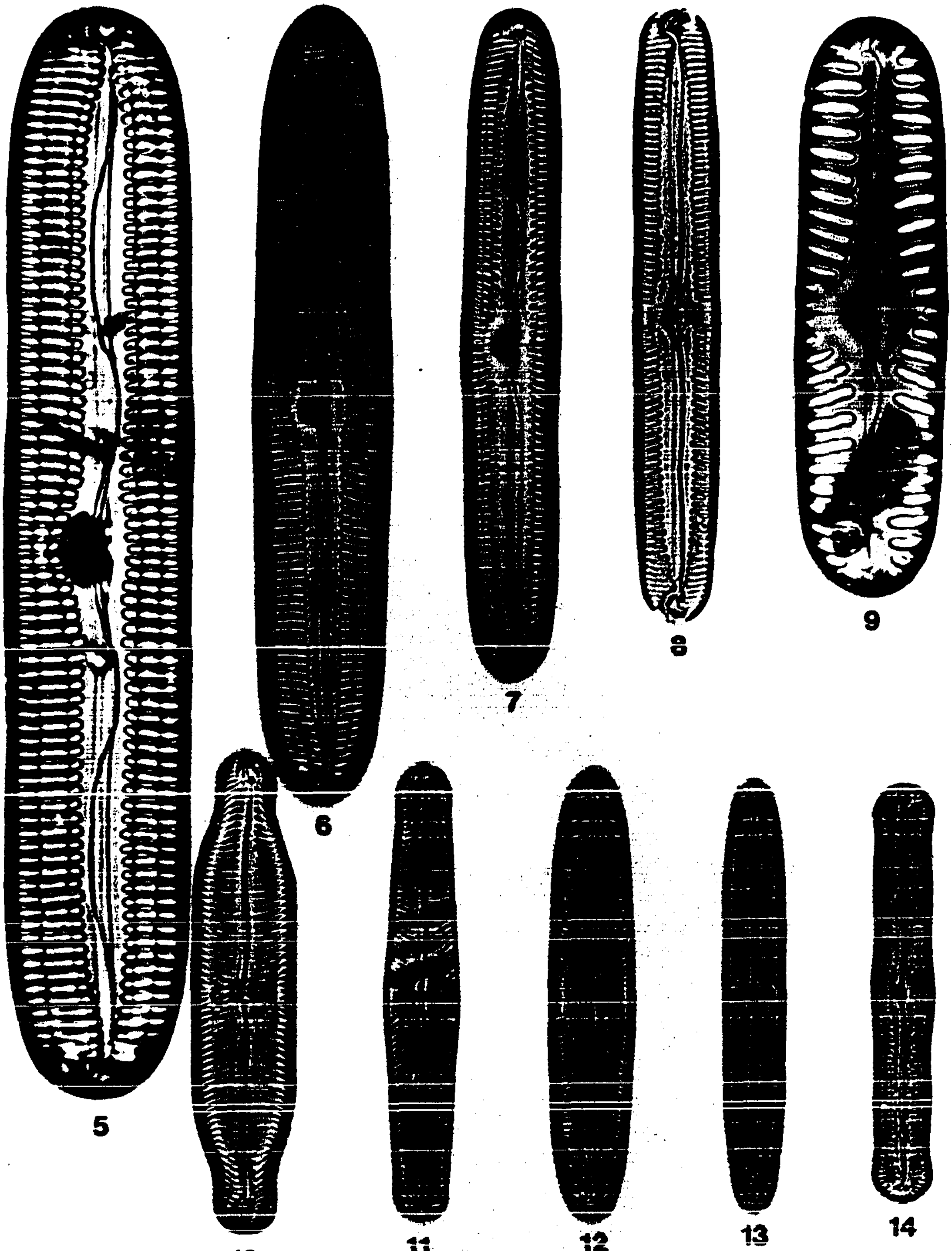

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Plate XLVII (continued)

Key to the species of _Pinnularia_ encountered in this study. X1000.

Fig. 15. _Pinnularia_ species #3.
vl: 61 µm, vb: 12 µm, s/10 µm: 9-10.

Fig. 16. _Pinnularia_ _braunii_ (Grun.) Cl. var. _braunii_.
vl: 52 µm, vb: 10 µm, s/10 µm: 10.

Fig. 17. _Pinnularia_ _abaujensis_ var. _subundulata_ (A. Mayer _ex_ Hust.) Patr.
vl: 52 µm, vb: 6 µm, s/10 µm: 12.

Fig. 18. _Pinnularia_ _biceps_ Greg. var. _biceps_.
vl: 51 µm, vb: 12 µm, s/10 µm: 11-12.

Fig. 19. _Pinnularia_ _nodosa_ (Ehr.) W. Sm. var. _nodosa_.
vl: 49 µm, vb: 8 µm, s/10 µm: 10.

Fig. 20. _Pinnularia_ _microstauron_ var. _brebissonii_ (Kütz.) Hust.
vl: 47 µm, vb: 10 µm, s/10 µm: 12.

Fig. 21. _Pinnularia_ species #2.
vl: 45 µm, vb: 8 µm, s/10 µm: 12.

Fig. 22. _Pinnularia_ _leptosoma_ Grun. var. _leptosoma_.
vl: 40 µm, vb: 6 µm, s/10 µm: 16.

Fig. 23. _Pinnularia_ _intermedia_ (Lagerst.) Cl. var. _intermedia_.
vl: 39 µm, vb: 7 µm, s/10 µm: 9-10.

Fig. 24. _Pinnularia_ _mesolepta_ fo. _angusta_ Cl.
vl: 36 µm, vb: 6 µm, s/10 µm: 11.

Fig. 25. _Pinnularia_ _interrupta_ W. Sm. var. _interrupta_.
vl: 34 µm, vb: 6 µm, s/10 µm: 13.

Fig. 26. _Pinnularia_ _obscura_ Krasske var. _obscura_.
vl: 33 µm, vb: 6 µm, s/10 µm: 11.

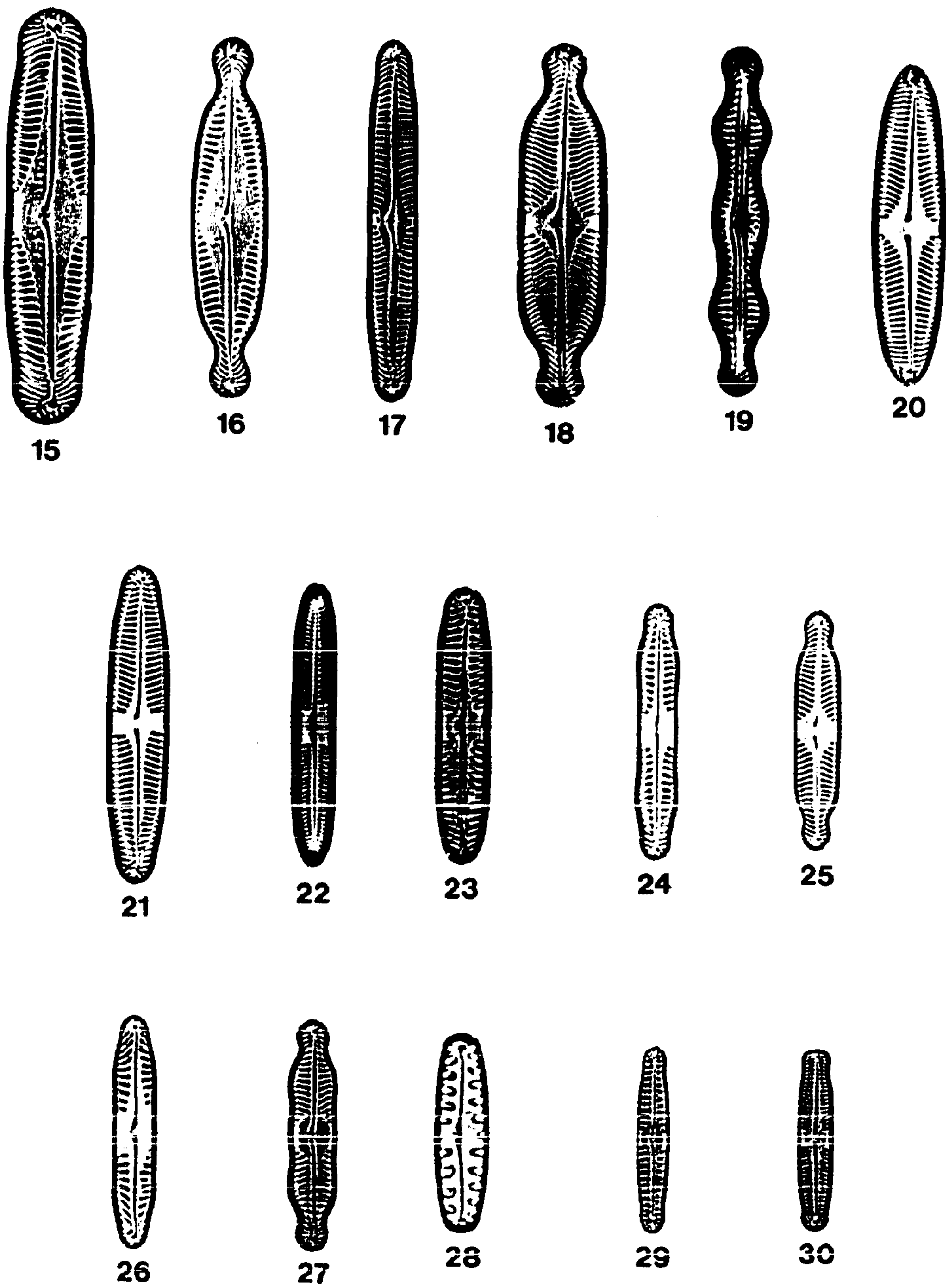
Fig. 27. _Pinnularia_ _mesolepta_ (Ehr.) W. Sm. var. _mesolepta_.
vl: 32 µm, vb: 7 µm, s/10 µm: 13.

Fig. 28. _Pinnularia_ _borealis_ Ehr. var. _borealis_.
vl: 28 µm, vb: 7 µm, s/10 µm: 4-5.

Fig. 29. _Pinnularia_ _subcapitata_ Greg. var. _subcapitata_.
vl: 27 µm, vb: 4 µm, s/10 µm: 11.

Fig. 30. _Pinnularia_ species #1.
vl: 26 µm, vb: 5 µm, s/10 µm: 15.

vl = valve length; vb = valve breadth; s/10 µm = number of striae per 10 µm interval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APPENDIX B:

DESCRIPTIONS OF SAMPLES AND LOCATIONS OF SAMPLING SITES

Sample #1: *Sphagnum* squeezing from the middle of the mat. Dead Man's Lake. Pilot Knob State Park. Section 4, Ellington Township, Hancock County, Iowa. T-97N, R-23W. Collected on June 29, 1976 by Harvey John.

Sample #2: Mud from exposed lake bed (long dry spell) - mud wet and frozen. Pilot Knob State Park. Section 4, Ellington Township, Hancock County, Iowa. T-97N, R-23W. Collected on November 4, 1976 by John D. Dodd.

Sample #3: Collection from small pools in the *Sphagnum* mat - includes *Sphagnum* squeezings. Dead Man's Lake. Pilot Knob State Park. Section 4, Ellington Township, Hancock County, Iowa. T-97N, R-23W. Collected on July 16, 1959 by the Iowa Lakeside Laboratory algae class.

Sample #4: Collection from a small pool in a drainage ditch near Big Creek Lake. Section 23, Madison Township, Polk County, Iowa. T-81N, R-25W. Collected on September 22, 1977 by John D. Dodd.

Sample #5: Soil from the face of a moist sandstone cliff at Bone Yard Hollow. Dolliver State Park. Section 35, Otho Township, Webster County, Iowa. T-88N, R-28W. Collected on October 6, 1977 by David C. Jackson.

Sample #6: Sand from the bottom and diatoms from rock surfaces of a small stream running through Bone Yard Hollow. Dolliver State Park. Section 35, Otho Township, Webster County, Iowa. T-88N, R-28W. Collected on October 6, 1977 by David C. Jackson.

Sample #7: Benthic sample from a quiet backwater area of the Des Moines River near Bone Yard Hollow. Dolliver State Park. Section 35, Otho Township, Webster County, Iowa. T-88N, R-28W. Collected on October 6, 1977 by David C. Jackson.

Sample #8: Benthic material from the dock area near the boat ramp. Don Williams Lake. Section 5, Yell Township, Boone County, Iowa. T-84N, R-27W. Collected on October 6, 1977 by David C. Jackson.

Sample #9: Collection from brown-water pools on *Carex* mat. Pilot Knob State Park. Section 4, Ellington Township, Hancock County, Iowa. T-97N, R-23W. Collected on October 1, 1977 by James L. Wee.

Sample #10: Squeezing from *Sphagnum* mat. Dead Man's Lake. Pilot Knob State Park. Section 4, Ellington Township, Hancock County, Iowa. T-97N, R-23W. Collected on October 1, 1977 by James L. Wee.

Sample #11: Bottom mud from an isolated pool at Pea's Creek. Ledges State Park. Section 20, Worth Township, Boone County, Iowa. T-83N, R-26W. Collected on October 13, 1977 by David C. Jackson.

Sample #12: Collection from rock surfaces at the lake's edge near the beach. Hickory Grove Park. Section 24, Nevada Township, Story County, Iowa. T-83N, R-22W. Collected on October 13, 1977 by David C. Jackson.

Sample #13: Collection of diatoms from the surface of a partially submerged log at the lake's edge. Hickory Grove Park. Section 24, Nevada Township, Story County, Iowa. T-83N, R-22W. Collected on October 13, 1977 by David C. Jackson.

Sample #14: Flocculent material attached to submerged plant stems. Hickory Grove Park. Section 24, Nevada Township, Story County, Iowa. T-83N, R-22W. Collected on October 13, 1977 by David C. Jackson.

Sample #15: Bubbly surface material from an iron-rich pool. Silver Lake Fen. Section 32, Silver Lake Township, Dickinson County, Iowa. T-100N, R-38W. Collected on July 13, 1977 by John D. Dodd.

Sample #16: Mud sample from small isolated pools near the lake shore. Mud Lake. Section 36, Lake Township, Clay County, Iowa. T-97N, R-35W. Collected on October 15, 1977 by David C. Jackson.

Sample #17: Collection of sand from the water's edge at Templar Park. Spirit Lake. Section 29, Spirit Lake Township, Dickinson County, Iowa. T-100N, R-36W. Collected on October 15, 1977 by David C. Jackson.

Sample #18: Collection of sediments and decomposing leaves from shallow water. Jemmerson Slough. Section 6, Center Grove Township, Dickinson County, Iowa. T-99N, R-36W. Collected on October 15, 1977 by James L. Wee.

Sample #19: Collection of sand and mud from the edge of Lazy Lagoon. West Lake Okoboji. Section 2, Lakeville Township, Dickinson County, Iowa. T-99N, R-37W. Collected on October 15, 1977 by David C. Jackson.

Sample #20: Collection of mud from near the road bridge. Little Sioux River at State Route 9. Section 31, Diamond Lake Township, Dickinson County, Iowa. T-100N, R-37W. Collected on October 15, 1977 by David C. Jackson.

Sample #21: Sediments from small pools in the short vegetation zone. Silver Lake Fen. Section 32, Silver Lake Township, Dickinson County, Iowa. T-100N, R-38W. Collected on October 15, 1977 by David C. Jackson.

Sample #22: Moss and sediments from small pools near the edge of the fen. Silver Lake Fen. Section 32, Silver Lake Township, Dickinson County, Iowa. T-100N, R-38W. Collected on October 15, 1977 by David C. Jackson.

Sample #23: Pool sediments and <u>Chara</u> squeezings. Excelsior Fen. Section 10, Excelsior Township, Dickinson County, Iowa. T-99N, R-38W. Collected on October 15, 1977 by James L. Wee.

Sample #24: Collection of sediments from the creek bottom. Dugout Creek near Excelsior Fen. Section 10, Excelsior Township, Dickinson County, Iowa. T-99N, R-38W. Collected on October 15, 1977 by David C. Jackson.

Sample #25: Collection of mud and mosses from the basin.

Freda Haffner Kettle Hole. Section 33, Lakeville Township, Dickinson County, Iowa. T-99N, R-37W. Collected on October 15, 1977 by David C. Jackson.

Sample #26: Collection from the surface of vegetation at the river's edge. Little Sioux River at Horseshoe Bend County Park. Section 16, Okoboji Township, Dickinson County, Iowa. T-98N, R-37W. Collected on October 15, 1977 by David C. Jackson.

Sample #27: Collection of sand and material from rock surfaces. Minnewashta Lake. Section 30, Center Grove Township, Dickinson County, Iowa. T-99N, R-36W. Collected on October 15, 1977 by David C. Jackson.

Sample #28: Collection of sand and material from rock surfaces at the water's edge. East Lake Okoboji. Section 20, Center Grove Township, Dickinson County, Iowa. T-99N, R-36W. Collected on October 15, 1977 by David C. Jackson.

Sample #29: Collection of mud from shallow water at the northwest end of the lake. Clear Lake. Section 15, Clear Lake Township, Cerro Gordo County, Iowa. T-96N, R-22W. Collected on October 20, 1977 by David C. Jackson.

Sample #30: Collection of material from the surfaces of submerged grasses. Iowa River at U.S. Route 69 just north of Belmond. Section 24, Belmond Township, Wright County, Iowa. T-93N, R-24W. Collected on October 20, 1977 by

David C. Jackson.

Sample #31: Collection of sediments from a puddle in the parking lot near the lake. Big Wall Lake. Section 11, Wall Lake Township, Wright County, Iowa. T-90N, R-24W. Collected on October 20, 1977 by David C. Jackson.

Sample #32: Collection of mud from a pool near a dense Phragmites stand. Big Wall Lake. Section 11, Wall Lake Township, Wright County, Iowa. T-90N, R-24W. Collected on October 20, 1977 by David C. Jackson.

Sample #33: Sediments from a borrow pit. Junction of U.S. Highway 30 and the West Ames exit. Section 11, Colfax Township, Boone County, Iowa. T-83N, R-25W. Collected on October 21, 1977 by James L. Wee.

Sample #34: Sediments from the dam area. Big Creek Reservoir. Section 26, Madison Township, Polk County, Iowa. T-81N, R-25W. Collected on October 21, 1977 by James L. Wee.

Sample #35: Collection of sediments and dead plant parts. Dakin Lake. Section 16, Lincoln Township, Story County, Iowa. T-85N, R-21W. Collected on October 22, 1977 by James L. Wee.

Sample #36: Psammon sample from the boat launch area. Upper Pine Lake. Section 4, Eldora Township, Hardin County, Iowa. T-87N, R-19W. Collected on October 22, 1977 by James L. Wee.

Sample #37: Psammon sample and submerged mosses from an inlet near the southern end of the lake.

Lower Pine Lake. Section 4, Eldora Township, Hardin County, Iowa. T-87N, R-19W. Collected on October 22, 1977 by James L. Wee.

Sample #38: Sediments from the surfaces of rocks near the shore. Limestone gravel pit about 5 miles northwest of Eldora. Section 12, Jackson Township, Hardin County, Iowa. T-88N, R-20W. Collected on October 22, 1977 by James L. Wee.

Sample #39: Composite sample of sediments from the dock area. Little Wall Lake. Section 9, Ellsworth Township, Hamilton County, Iowa. T-86N, R-24W. Collected on October 22, 1977 by James L. Wee.

Sample #40: Collection from the Sphagnum mat. Dead Man's Lake. Pilot Knob State Park. Section 4, Ellington Township, Hancock County, Iowa. T-97N, R-23W. Collected on July 4, 1977 by J. Rohret and M. Weber.

Sample #41: Sample from a hanging bog. Mill Creek. Section 24, Okoboji Township, Dickinson County, Iowa. T-98N, R-37W. Collected on June 10, 1965 by John D. Dodd and E.J. Fee.

Sample #42: Sediments from small pools on the Sphagnum mat. Dead Man's Lake. Pilot Knob State Park. Section 4, Ellington Township, Hancock County, Iowa. T-97N, R-23W. Collected on June 3, 1978 by David C. Jackson.

Sample #43: Sediments from small pools on the Sphagnum mat. Dead Man's Lake. Pilot Knob State Park. Section 4, Ellington Township, Hancock County, Iowa. T-97N, R-23W. Collected on June 3, 1978 by David C. Jackson.

Sample #44: Sediments from a heavily vegetated zone at the northwest end of the lake. Dead Man's Lake. Pilot Knob State Park. Section 4, Ellington Township, Hancock County, Iowa. T-97N, R-23W. Collected on June 3, 1978 by David C. Jackson.

Sample #45: Sediments and plant squeezings from the northern end of the lake. Dead Man's Lake. Pilot Knob State Park. Section 4, Ellington Township, Hancock County, Iowa. T-97N, R-23W. Collected on June 3, 1978 by David C. Jackson.

Sample #46: Sediments and squeezings from floating algae and dead plant material at the eastern end of the lake. Dead Man's Lake. Pilot Knob State Park. Section 4, Ellington Township, Hancock County, Iowa. T-97N, R-23W. Collected on June 3, 1978 by David C. Jackson.

Sample #47: Squeezings from submerged plant material at the southwestern end of the lake. Dead Man's Lake. Pilot Knob State Park. Section 4, Ellington Township, Hancock County, Iowa. T-97N, R-23W. Collected on June 3, 1978 by David C. Jackson.

Sample #48: Sediments and Sphagnum squeezings from the southwestern end of the Sphagnum mat. Dead Man's Lake. Pilot Knob State Park. Section 4, Ellington Township, Hancock County, Iowa. T-97N, R-23W. Collected on June 3, 1978 by David C. Jackson.

Sample #49: Sediments from an isolated pool at the western end of the lake. Crystal Lake. Section 9, Crystal Township, Hancock County, Iowa. T-97N, R-25W. Collected on June 3, 1978 by David C. Jackson.

Sample #50: Sediments collected near a road bridge. Iowa River about 5 miles south of Belmond on U.S. Route 69. Section 25, Grant Township, Wright County, Iowa. T-92N, R-24W. Collected on June 3, 1978 by David C. Jackson.

Sample #51: Sediments and floating algae from a boat access at the eastern end of the lake. Big Wall Lake. Section 11, Wall Lake Township, Wright County, Iowa. T-90N, R-24W. Collected on June 3, 1978 by David C. Jackson.

Sample #52: Sediments and floating algae from a _Typha_ bed. Pond near Big Wall Lake. Section 11, Wall Lake Township, Wright County, Iowa. T-90N, R-24W. Collected on June 3, 1978 by David C. Jackson.

Sample #53: Sediments and filamentous algae from rock surfaces at the western end of the lake. Little Wall Lake. Section 9, Ellsworth Township, Hamilton County, Iowa. T-86N, R-24W. Collected on June 3, 1978 by David C. Jackson.

Sample #54: Sediments from a seepage area in a pasture north of Iowa Lakeside Laboratory. Section 23, Lakeville Township, Dickinson County, Iowa. T-99N, R-37W. Collected on June 10, 1978 by David C. Jackson.

Sample #55: Mosses from a seepage area in a pasture north of Iowa Lakeside Laboratory. Section 23, Lakeville Township, Dickinson County, Iowa. T-99N, R-37W. Collected on June 10, 1978 by David C. Jackson.

Sample #56: Sediments and plant squeezings from the western edge of Little Miller's Bay. West Lake Okoboji. Section 23, Lakeville Township, Dickinson County, Iowa. T-99N, R-37W. Collected on June 10, 1978 by David C. Jackson.

Sample #57: Sediments from rock surfaces at the Iowa Lakeside Laboratory boat dock. West Lake Okoboji. Section 23, Lakeville Township, Dickinson County, Iowa. T-99N, R-37W. Collected on June 10, 1978 by David C. Jackson.

Sample #58: Sediments and dead leaves from a small open area in the sedge mat at the southern end of the basin. Freda Haffner Kettle Hole. Section 33, Lakeville Township, Dickinson County, Iowa. T-99N, R-37W. Collected on June 10, 1978 by David C. Jackson.

Sample #59: Sediments and plant squeezings from a small pool in the sedge mat at the southern end of the basin. Freda Haffner Kettle Hole. Section 33, Lakeville Township, Dickinson County, Iowa. T-99N, R-37W. Collected on June 10, 1978 by David C. Jackson.

Sample #60: Bottom sediments from an open water area at the southern end of the basin. Freda Haffner Kettle Hole. Section 33, Lakeville Township, Dickinson County, Iowa. T-99N, R-37W. Collected on June 10, 1978 by David C. Jackson.

Sample #61: Sediments from a small open area in the vegetation at the southeastern end of the basin. Freda Haffner Kettle Hole. Section 33, Lakeville Township, Dickinson County, Iowa. T-99N, R-37W. Collected on June 10, 1978 by David C. Jackson.

Sample #62: Sediments and plant squeezings from an open pool at the northeastern end of the basin. Freda Haffner Kettle Hole. Section 33, Lakeville Township, Dickinson County, Iowa. T-99N, R-37W. Collected on June 10, 1978 by David C. Jackson.

Sample #63: Sediments and plant squeezings from an open area near the fence at the southwestern pond. Three Corner Ponds. Section 3, Okoboji Township, Dickinson County, Iowa. T-98N, R-37W. Collected on June 10, 1978 by David C. Jackson.

Sample #64: Sediments and algal squeezings from the eastern edge of the northwestern pond. Three Corner Ponds. Section 34, Lakeville Township, Dickinson County, Iowa. T-99N, R-37W. Collected on June 10, 1978 by David C. Jackson.

Sample #65: Sediments and algae from a small open area in tall vegetation in the northeastern pond. Three Corner Ponds. Section 35, Lakeville Township, Dickinson County, Iowa. T-99N, R-37W. Collected on June 10, 1978 by David C. Jackson.

Sample #66: Moist surface mud from an exposed area. Pothole north of Cayler Prairie. Section 8, Lakeville Township, Dickinson County, Iowa. T-99N, R-37W. Collected on June 10, 1978 by David C. Jackson.

Sample #67: Flocculent material from a small pool in the short vegetation zone. Silver Lake Fen. Section 32, Silver Lake Township, Dickinson County, Iowa. T-100N, R-38W. Collected on June 10, 1978 by David C. Jackson.

Sample #68: Surface scum from an iron-rich pool. Silver Lake Fen. Section 32, Silver Lake Township, Dickinson County, Iowa. T-100N, R-38W. Collected on June 10, 1978 by David C. Jackson.

Sample #69: Bottom sediments from an iron-rich pool. Silver Lake Fen. Section 32, Silver Lake Township, Dickinson County, Iowa. T-100N, R-38W. Collected on June 10, 1978 by David C. Jackson.

Sample #70: Sediments from an iron-rich seepage area. Seepage area east of Silver Lake Fen. Section 32, Silver Lake Township, Dickinson County, Iowa. T-100N, R-38W. Collected on June 10, 1978 by David C. Jackson.

Sample #71: Algae and sediments from a small pool at the end of a drainage pipe. Drainage pipe east of Silver Lake Fen. Section 32, Silver Lake Township, Dickinson County, Iowa. T-100N, R-38W. Collected on June 10, 1978 by David C. Jackson.

Sample #72: Squeezings from floating algae at a beach at the southern end of the lake. Spirit Lake. Section 28, Spirit Lake Township, Dickinson County, Iowa. T-100N, R-36W. Collected on June 10, 1978 by David C. Jackson.

Sample #73: Clumps of mosses from the fen. Silver Lake Fen. Section 32, Silver Lake Township, Dickinson County, Iowa. T-100N, R-38W. Collected on June 10, 1978 by John D. Dodd.

Sample #74: Mud from a small drying marsh pond at the parking lot by the old fish weir separating Lower Gar Lake from Minnewashta Lake. Section 29, Center Grove Township, Dickinson County, Iowa. T-99N, R-36W. Collected on June 13, 1978 by John D. Dodd.

Sample #75: Sediments from mud and rock surfaces. Iowa River at State Route 175 east of Eldora. Section 8, Eldora Township, Hardin County, Iowa. T-87N, R-19W. Collected on September 10, 1978 by David C. Jackson.

Sample #76: Sediments from mud and wood surfaces. Cedar River at State Route 101. Section 16, Taylor Township, Benton County, Iowa. T-85N, R-10W. Collected on September 10, 1978 by David C. Jackson.

Sample #77: Sediments from a mud surface. Wapsipinicon River at State Route 13. Section 3, Maine Township, Linn County, Iowa. T-85N, R-6W. Collected on September 10, 1978 by David

C. Jackson.

Sample #78: Sediments from a mud surface. Maquoketa River at U.S. Route 20. Section 29, Delaware Township, Delaware County, Iowa. T-89N, R-5W. Collected on September 10, 1978 by David C. Jackson.

Sample #79: Sediments from rock surfaces near a spillway. Wapsipinicon River at U.S. Route 20. Section 34, Washington Township, Buchanan County, Iowa. T-89N, R-9W. Collected on September 10, 1978 by David C. Jackson.

Sample #80: Sediments from mud, rock, and wood surfaces. Cedar River at U.S. Route 20. Section 1, Cedar Falls Township, Black Hawk County, Iowa. T-89N, R-14W. Collected on September 10, 1978 by David C. Jackson.

Sample #81: Sediments from rock and wood surfaces. Shell Rock River at State Route 188. Section 19, Butler Township, Butler County, Iowa. T-92N, R-15W. Collected on September 11, 1978 by David C. Jackson.

Sample #82: Sediments from rock surfaces. Cedar River at State Route 3. Section 2, Washington Township, Bremer County, Iowa. T-91N, R-14W. Collected on September 11, 1978 by David C. Jackson.

Sample #83: Sediments from mud, wood, and rock surfaces. Wapsipinicon River at State Route 3. Section 8, Franklin Township, Bremer County, Iowa. T-91N, R-11W. Collected on September 11, 1978 by David C. Jackson.

Sample #84: Sediments from mud and rock surfaces. Cedar River at U.S. Route 218. Section 16, Floyd Township, Floyd County, Iowa. T-96N, R-16W. Collected on September 11, 1978 by David C. Jackson.

Sample #85: Sediments from mud and rock surfaces. Little Cedar River at County Road T64. Section 16, Niles Township, Floyd County, Iowa. T-96N, R-15W. Collected on September 11, 1978 by David C. Jackson.

Sample #86: Sediments from a mud surface. Wapsipinicon River at County Road B28. Section 9, Deerfield Township, Chickasaw County, Iowa. T-96N, R-14W. Collected on September 11, 1978 by David C. Jackson.

Sample #87: Sediments from rock surfaces. Winnebago River at U.S. Route 18. Section 11, Mason Township, Cerro Gordo County, Iowa. T-96N, R-20W. Collected on September 11, 1978 by David C. Jackson.

Sample #88: Sediments from a mud surface. East Branch of the Iowa River at U.S. Route 18. Section 25, Garfield Township, Hancock County, Iowa. T-96N, R-24W. Collected on September 11, 1978 by David C. Jackson.

Sample #89: Sediments from a mud surface. West Branch of the Iowa River at U.S. Route 18. Section 27, Britt Township, Hancock County, Iowa. T-96N, R-25W. Collected on September 11, 1978 by David C. Jackson.

Sample #90: Sediments from a mud surface. Winnebago River at U.S. Route 69. Section 36, Forest Township, Winnebago County, Iowa. T-98N, R-24W. Collected on September 11, 1978 by David C. Jackson.

Sample #91: Sediments from the surfaces of submerged grasses. Rice Lake. Section 13, Center Township, Winnebago County, Iowa. T-99N, R-23W. Collected on September 11, 1978 by David C. Jackson.

Sample #92: Sediments from mud and rock surfaces. Shell Rock River at State Route 105. Section 32, Grove Township, Worth County, Iowa. T-100N, R-20W. Collected on September 11, 1978 by David C. Jackson.

Sample #93: Sediments from sand, rock, and wood surfaces. Cedar River at State Route 105. Section 14, Newburg Township, Mitchell County, Iowa. T-99N, R-18W. Collected on September 11, 1978 by David C. Jackson.

Sample #94: Sediments from sand and wood surfaces. Little Cedar River at County Road A31. Section 22, Liberty Township, Mitchell County, Iowa. T-99N, R-16W. Collected on September 11, 1978 by David C. Jackson.

Sample #95: Sediments from mud and rock surfaces. Upper Iowa River at U.S. Route 52. Section 8, Decorah Township, Winneshiek County, Iowa. T-98N, R-8W. Collected on September 11, 1978 by David C. Jackson.

Sample #96: Sediments from mud and rock surfaces. Turkey River at U.S. Route 18. Section 34, Clermont

Township, Fayette County, Iowa. T-95N, R-7W. Collected on September 11, 1978 by David C. Jackson.

Sample #97: Sediments from mud and rock surfaces. Turkey River at U.S. Route 13. Section 23, Boardman Township, Clayton County, Iowa. T-93N, R-5W. Collected on September 11, 1978 by David C. Jackson.

Sample #98: Sediments from mud and rock surfaces. Volga River at County Road C2W. Section 10, Sperry Township, Clayton County, Iowa. T-92N, R-6W. Collected on September 11, 1978 by David C. Jackson.

Sample #99: Sediments from a sand surface. Maquoketa River at State Route 136. Section 6, Clay Township, Jones County, Iowa. T-85N, R-1W. Collected on September 11, 1978 by David C. Jackson.

Sample #100: Sediments from mud surfaces. Maquoketa River at State Route 62. Section 17, Maquoketa Township, Jackson County, Iowa. T-84N, R-3E. Collected on September 15, 1978 by David C. Jackson.

Sample #101: Sediments from the surface of mud at the edge of the river and from isolated pools. Wapsipinicon River at State Route 38. Section 12, Rome Township, Jones County, Iowa. T-83N, R-3W. Collected on September 15, 1978 by David C. Jackson.

Sample #102: Sediments from the surfaces of mud, sticks, and rocks. Cedar River at U.S. Route 30. Section 9, Putnam Township, Linn County, Iowa. T-82N, R-6W. Collected on September 15, 1978 by David C. Jackson.

Sample #103: Attached algae and sediments from sand and rock surfaces. Coralville Reservoir. Section 22, Jefferson Township, Johnson County, Iowa. T-81N, R-7W. Collected on September 15, 1978 by David C. Jackson.

Sample #104: Sediments from rock and sand surfaces. Iowa River at County Road W66. Section 33, Penn Township, Johnson County, Iowa. T-80N, R-6W. Collected on September 15, 1978 by David C. Jackson.

Sample #105: Sediments from rock and mud surfaces. Cedar River at County Road F36. Section 18, Cass Township, Cedar County, Iowa. T-80N, R-4W. Collected on September 15, 1978 by David C. Jackson.

Sample #106: Sediments from surfaces of sand, mud, and sticks. Wapsipinicon River at U.S. Route 30. Section 11, Spring Rock Township, Clinton County, Iowa. T-81N, R-1E. Collected on September 15, 1978 by David C. Jackson.

Sample #107: Sediments from the river's edge and from isolated pools. Iowa River at State Route 220. Section 36, Washington Township, Iowa County, Iowa. T-81N, R-10W. Collected on September 15, 1978 by David C. Jackson.

Sample #108: Sediments from a semi-isolated pool. Iowa

River at U.S. Route 63. Section 34, Tama Township, Tama County, Iowa. T-83N, R-15W. Collected on September 15, 1978 by David C. Jackson.

Sample #109: Sediments from a mud surface. Iowa River at State Route 14. Section 23, Taylor Township, Marshall County, Iowa. T-84N, R-18W. Collected on September 15, 1978 by David C. Jackson.

Sample #110: Sediments from mud and sand surfaces. East Indian Creek at U.S. Route 30. Section 14, Nevada Township, Story County, Iowa. T-83N, R-22W. Collected on September 16, 1978 by David C. Jackson.

Sample #111: Sediments from a mud surface. North Skunk River at State Route 223. Section 21, Malaka Township, Jasper County, Iowa. T-81N, R-19W. Collected on September 16, 1978 by David C. Jackson.

Sample #112: Sediments from a mud surface. Skunk River at State Route 14. Section 29, Palo Alto Township, Jasper County, Iowa. T-79N, R-19W. Collected on September 16, 1978 by David C. Jackson.

Sample #113: Sediments from the river bottom and from an isolated pool near the river. Des Moines River at State Route 14 at the Red Rock Reservoir. Section 36, Red Rock Township, Marion County, Iowa. T-77N, R-20W. Collected on September 16, 1978 by David C. Jackson.

Sample #114: Sediments from mud and sand surfaces. Des Moines River at State Route 92. Section 19, Scott Township, Mahaska County, Iowa. T-75N, R-17W. Collected on September 16, 1978 by David C. Jackson.

Sample #115: Sediments from a mud surface. South Skunk River at U.S. Route 63. Section 25, Madison Township, Mahaska County, Iowa. T-76N, R-16W. Collected on September 16, 1978 by David C. Jackson.

Sample #116: Diatom growths from a mud surface. North Skunk River at U.S. Route 63. Section 16, Union Township, Mahaska County, Iowa. T-77N, R-15W. Collected on September 16, 1978 by David C. Jackson.

Sample #117: Diatom growth from a mud surface. North Fork of the English River at U.S. Route 63. Section 13, Pleasant Township, Poweshiek County, Iowa. T-79N, R-15W. Collected on September 16, 1978 by David C. Jackson.

Sample #118: Diatom growths from a sand surface. North Fork of the English River at County Road F52. Section 1, English Township, Iowa County, Iowa. T-78N, R-11W. Collected on September 16, 1978 by David C. Jackson.

Sample #119: Diatom growths from mud and sand surfaces. South Fork of the English River at State Route 149. Section 14, English River Township, Keokuk County, Iowa. T-77N, R-11W. Collected on September 16, 1978 by David C. Jackson.

Sample #120: Diatom growth from a mud surface. North Skunk River at State Route 149. Section 14, Sigourney Township, Keokuk County, Iowa. T-75N, R-12W. Collected on September 16, 1978 by David C. Jackson.

Sample #121: Sediments from mud and clay surfaces. South Skunk River at State Route 149. Section 2, West Lancaster Township, Keokuk County, Iowa. T-74N, R-12W. Collected on September 16, 1978 by David C. Jackson.

Sample #122: Sediments from a mud surface just upstream from a riffle area. Cedar Creek at County Road V5H. Section 21, Highland Township, Wapello County, Iowa. T-73N, R-13W. Collected on September 16, 1978 by David C. Jackson.

Sample #123: Sediments from the surfaces of sand, rocks, and wood in the wave-wash zone. Des Moines River near U.S. Route 63 in Ottumwa. Section 25, Center Township, Wapello County, Iowa. T-72N, R-14W. Collected on September 16, 1978 by David C. Jackson.

Sample #124: Sediments from the surfaces of mud and rocks and from an isolated pool. Big Cedar Creek at State Route 1. Section 13, Center Township, Jefferson County, Iowa. T-71N, R-10W. Collected on September 16, 1978 by David C. Jackson.

Sample #125: Sediments from the surfaces of mud and rocks. Skunk River at U.S. Route 218. Section 4, Jackson Township, Henry County, Iowa. T-70N, R-6W. Collected on October 7, 1978 by David C. Jackson.

Sample #126: Sediments from a mud surface. Skunk River at County Road H28. Section 36, Walnut Township, Jefferson County, Iowa. T-73N, R-8W. Collected on October 7, 1978 by David C. Jackson.

Sample #127: Sediments from mud and rock surfaces and diatom growths from an isolated pool. English River at State Route 1. Section 18, English River Township, Washington County, Iowa. T-77N, R-7W. Collected on October 7, 1978 by David C. Jackson.

Sample #128: Sediments from a mud surface. Iowa River at State Route 70. Section 19, Columbus City Township, Louisa County, Iowa. T-75N, R-4W. Collected on October 7, 1978 by David C. Jackson.

Sample #129: Sediments from the surfaces of mud and rocks. Cedar River at State Route 22. Section 21, Pike Township, Muscatine County, Iowa. T-77N, R-3W. Collected on October 7, 1978 by David C. Jackson.

Sample #130: Diatom growths from a mud surface. Iowa River at U.S. Route 61. Section 9, Grandview Township, Louisa County, Iowa. T-74N, R-3W. Collected on October 7, 1978 by David C. Jackson.

Sample #131: Diatom growths from mud and rock surfaces. Iowa River at State Route 99. Section 22, Jefferson Township, Louisa County, Iowa. T-73N, R-2W. Collected on October 7, 1978 by David C. Jackson.

Sample #132: Sediments from mud and rock surfaces. Skunk River at U.S. Route 61. Section 33, Green Bay Township, Lee County, Iowa. T-69N, R-3W. Collected on October 7, 1978 by David C. Jackson.

Sample #133: Sediments from the surfaces of rocks and clay. Des Moines River at State Route 2. Section 35, Farmington Township, Van Buren County, Iowa. T-68N, R-8W. Collected on October 7, 1978 by David C. Jackson.

Sample #134: Sediments from the surfaces of wood and mud. Des Moines River at State Route 1. Section 36, Van Buren Township, Van Buren County, Iowa. T-69N, R-10W. Collected on October 7, 1978 by David C. Jackson.

Sample #135: Diatom growths from the surfaces of sand and sticks. Fox River at County Road J40. Section 27, Perry Township, Davis County, Iowa. T-69N, R-13W. Collected on October 14, 1978 by David C. Jackson.

Sample #136: Sediments from rock and wood surfaces and squeezings from submerged aquatic plants. Lake Wapello. Section 34, Marion Township, Davis County, Iowa. T-70N, R-15W. Collected on October 14, 1978 by David C. Jackson.

Sample #137: Sediments from sand and rock surfaces. Rathbun Lake. Section 10, Independence Township, Appanoose County, Iowa. T-70N, R-19W. Collected on October 14, 1978 by David C. Jackson.

Sample #138: Diatom growth from a mud surface. South Fork of the Chariton River at State Route 2. Section 21, Benton Township, Wayne County, Iowa. T-69N, R-22W. Collected on October 14, 1978 by David C. Jackson.

Sample #139: Sediments from a clay surface. Chariton River at U.S. Route 65. Section 14, Union Township, Lucas County, Iowa. T-71N, R-23W. Collected on October 14, 1978 by David C. Jackson.

Sample #140: Diatom growths from the surfaces of mud and sticks. Whitebreast Creek at County Road S23. Section 14, Liberty Township, Lucas County, Iowa. T-73N, R-22W. Collected on October 14, 1978 by David C. Jackson.

Sample #141: Diatom growths from a sand surface. South River at U.S. Route 69. Section 6, Otter Township, Warren County, Iowa. T-75N, R-23W. Collected on October 14, 1978 by David C. Jackson.

Sample #142: Diatom growth from a mud surface. Skunk River at County Road F22. Section 30, Washington Township, Polk County, Iowa. T-81N, R-22W. Collected on October 14, 1978 by David C. Jackson.

Sample #143: Sediments from the surfaces of sand, mud, and rocks. Skunk River at Lincoln Way in Ames. Section 1, Washington Township, Story County, Iowa. T-83N, R-24W. Collected on October 14, 1978 by David C. Jackson.

Sample #144: Sediments from sand and rock surfaces. Weldon River at State Route 2. Section 20, High Point Township, Decatur County, Iowa. T-69N, R-24W. Collected on October 16, 1978 by David C. Jackson.

Sample #145: Diatom growth from a sand surface. Thompson River at State Route 2. Section 33, Decatur Township, Decatur County, Iowa. T-69N, R-26W. Collected on October 16, 1978 by David C. Jackson.

Sample #146: Diatom growth from a clay surface. East Fork of the Grand River at State Route 2. Section 3, Poe Township, Ringgold County, Iowa. T-68N, R-29W. Collected on October 16, 1978 by David C. Jackson.

Sample #147: Sediments from a sand surface. West Fork of the Grand River at State Route 2. Section 3, Rice Township, Ringgold County, Iowa. T-68N, R-30W. Collected on October 16, 1978 by David C. Jackson.

Sample #148: Diatom growths from sand and leaf surfaces. Platte River at State Route 2. Section 3, Waubonsie Township, Ringgold County, Iowa. T-68N, R-31W. Collected on October 16, 1978 by David C. Jackson.

Sample #149: Diatom growths from the surfaces of sand and a corn cob. Nodaway River at State Route 2. Section 32, Nodaway Township, Page County, Iowa. T-69N, R-36W. Collected on October 16, 1978 by David C. Jackson.

Sample #150: Sediments from mud and rock surfaces and squeezings from mats of Cladophora. Middle Tarkio River at State Route 2. Section 27, Tarkio Township, Page County, Iowa. T-69N, R-38W. Collected on October 16, 1978 by David C. Jackson.

Sample #151: Diatom growths from sand, sticks, rocks, and filamentous algae. Fisher Creek at County Road J42. Section 27, Fisher Township, Fremont County, Iowa. T-69N, R-40W. Collected on October 16, 1978 by David C. Jackson.

Sample #152: Diatom growths from mud and sand surfaces. Nishnabotna River at State Route 2. Section 13, Walnut Township, Fremont County, Iowa. T-69N, R-40W. Collected on October 16, 1978 by David C. Jackson.

Sample #153: Diatom growth from a mud surface. West Nishnabotna River at State Route 2. Section 29, Prairie Township, Fremont County, Iowa. T-69N, R-41W. Collected on October 16, 1978 by David C. Jackson.

Sample #154: Diatom growth from a sand surface. Silver Creek at U.S. Route 34. Section 19, Silver Creek Township, Mills County, Iowa. T-72N, R-41W. Collected on October 16, 1978 by David C. Jackson.

Sample #155: Diatom growth from a sand surface. Nishnabotna River at U.S. Route 34. Section 24, Indian Creek Township, Mills County, Iowa. T-72N, R-41W. Collected on October 16, 1978 by David C. Jackson.

Sample #156: Diatom growth from a sand surface. Walnut Creek at U.S. Route 34. Section 23, Garfield Township, Montgomery County, Iowa. T-72N, R-39W. Collected on October 16, 1978 by

David C. Jackson.

Sample #157: Diatom growth from a sand surface. Nishnabotna River at U.S. Route 34. Section 20, Red Oak Township, Montgomery County, Iowa. T-72N, R-38W. Collected on October 16, 1978 by David C. Jackson.

Sample #158: Diatom growth from a mud surface. Tarkio Creek at U.S. Route 34. Section 33, Frankfort Township, Montgomery County, Iowa. T-72N, R-37W. Collected on October 16, 1978 by David C. Jackson.

Sample #159: Diatom growth from a sand surface. West Nodaway River at U.S. Route 34. Section 4, East Jackson Township, Montgomery County, Iowa. T-71N, R-36W. Collected on October 16, 1978 by David C. Jackson.

Sample #160: Diatom growth from a sand surface. Middle Nodaway River at U.S. Route 34. Section 1, East Jackson Township, Montgomery County, Iowa. T-71N, R-36W. Collected on October 16, 1978 by David C. Jackson.

Sample #161: Diatom growth from a mud surface. West Platte River at U.S. Route 34. Section 2, Grant Township, Adams County, Iowa. T-71N, R-32W. Collected on October 16, 1978 by David C. Jackson.

Sample #162: Sediments from rock surfaces. Summit Lake. Section 35, Spaulding Township, Union County, Iowa. T-73N, R-31W. Collected on October 16, 1978 by David C. Jackson.

Sample #163: Diatom growths from the surfaces of mud and rocks. Thompson River at U.S. Route 34. Section 20, Jones Township, Union County, Iowa. T-72N, R-28W. Collected on October 16, 1978 by David C. Jackson.

APPENDIX C:

PINNULARIA TAXA REPORTED FROM IOWA IN THE PUBLISHED LITERATURE OR IN UNPUBLISHED THESES AND DISSERTATIONS FROM IOWA STATE UNIVERSITY

Pinnularia abaujensis (Pant.) Ross var. abaujensis

Reported by: Christensen, C. L. 1976. From Dead Man's Lake, Hancock County, Iowa.

Myers, P. C. 1898b. From fossil diatomaceous earth, Muscatine County, Iowa. (cited as Navicula abaujensis Pant.)

Reimer, C. W. 1970. From a soil sample at Cayler Prairie, Dickinson County, Iowa.

Pinnularia abaujensis var. linearis (Hust.) Patr.

Reported by: Christensen, C. L. 1976. From Dead Man's Lake, Hancock County, Iowa.

Gudmundson, B. J. R. 1969. From the plankton of the upper Des Moines River, Iowa.

Gudmundson, B. J. R. 1972. From the plankton of the upper Des Moines River, Iowa.

Hungerford, J. J. 1971. From the Raccoon River, Buena Vista County, Iowa.

Pinnularia abaujensis var. rostrata (Patr.) Patr.

Reported by: Christensen, C. L. 1976. From Dead Man's Lake, Hancock County, Iowa.

Pinnularia abaujensis var. subundulata (A. Mayer ex Hust.) Patr.

Reported by: Christensen, C. L. 1976. From Dead Man's Lake, Hancock County, Iowa.

Shobe, W. R. 1967. From the Skunk River, Story County, Iowa. (cited as Pinnularia abaujensis var. subundulata (Pant.) Ross)

Pinnularia acrosphaeria W. Sm. var. acrosphaeria

Reported by: Begres, F. M. 1971. From Ventura Marsh, Cerro Gordo and Hancock Counties, Iowa.

Christensen, C. L. 1976. From Dead Man's Lake, Hancock County, Iowa.

Drum, R. W. 1964. From the Des Moines River, Iowa. (cited as _Pinnularia acrosphaeria_ Breb.)

Lowe, R. L. 1970. From drainage ditches, Story County, Iowa.

Lowe, R. L. 1972b. From drainage ditches, Story County, Iowa.

Ohl, L. E. 1965. From a farm pond, Clarke County, Iowa. (cited as _Pinnularia acrosphaeria_ Breb.)

Schmidt, D. J., and E. J. Fee. 1967. From the plankton of the Coralville Reservoir, Johnson County, Iowa. (cited as _Pinnularia acrosphaeria_ Breb.)

Pinnularia acrosphaeria var. _dubia_ Guermeur

Reported by: Ohl, L. E. 1965. From a farm pond, Clarke County, Iowa.

Pinnularia acrosphaeria fo. _undulata_ Cl.

Reported by: Christensen, C. L. 1976. From Dead Man's Lake, Hancock County, Iowa.

Pinnularia acuminata var. _interrupta_ (Cl.) Patr.

Reported by: Lowe, R. L. 1970. From a drainage ditch, Story County, Iowa.

Pinnularia aequalis Ehr. var. _aequalis_

Reported by: Ehrenberg, C. G. 1856. From the Des Moines River near Fort Dodge, Webster County, Iowa.

Pinnularia aequilateralis Patr. and Freese var. _aequilateralis_

Reported by: Stoermer, E. F. 1963. From Lake West Okoboji, Dickinson County, Iowa.

Stoermer, E. F. 1964. From Lake West Okoboji, Dickinson County, Iowa.

Pinnularia amphioxys Ehr. var. amphioxys

Reported by: Ehrenberg, C. G. 1856. From the Des Moines River near Fort Dodge, Webster County, Iowa.

Pinnularia andreei Foged var. andreei

Reported by: Christensen, C. L. 1976. From Dead Man's Lake, Hancock County, Iowa.

Pinnularia appendiculata (Agardh) Cl. var. appendiculata

Reported by: Collins, G. B. 1968. From cores of Little Miller's Bay (Lake West Okoboji) and of the Arend's Kettle Hole, Dickinson County, Iowa.

Stoermer, E. F. 1962. From South Falls, Marion County, Iowa. (cited as an unknown species which belongs in the series of forms of Pinnularia appendiculata)

Stoermer, E. F. 1963. From Lake West Okoboji, Dickinson County, Iowa.

Pinnularia biceps Greg. var. biceps

Reported by: Beckert, C. A. 1977. From the Skunk River, Story County, Iowa.

Begres, F. M. 1971. From Ventura Marsh, Cerro Gordo and Hancock Counties, Iowa.

Christensen, C. L. 1976. From Dead Man's Lake, Hancock County, Iowa.

Hungerford, J. J. 1972. From Pillsbury Lake bed, Dickinson County, Iowa.

Schmidt, D. J., and E. J. Fee. 1967. From the plankton of the Coralville Reservoir, Johnson County, Iowa.

Pinnularia biceps fo. petersenii Ross

Reported by: Christensen, C. L. 1976. From Dead Man's Lake, Hancock County, Iowa.

Edwards, M. L. 1974. From a drainage tile near Big Spirit Lake, Dickinson County, Iowa.

Lowe, R. L. 1970. From a drainage ditch, Story County, Iowa.

Lowe, R. L. 1972a. From a drainage ditch, Story County, Iowa.

Lowe, R. L. 1972b. From a drainage ditch, Story County, Iowa.

Pinnularia bogotensis var. undulata (M. Perag.) Boyer

Reported by: Christensen, C. L. 1976. From Dead Man's Lake, Hancock County, Iowa.

Pinnularia borealis Ehr. var. borealis

Reported by: Begres, F. M. 1971. From Clear Lake, Cerro Gordo County, Iowa.

Christensen, C. L. 1976. From Dead Man's Lake, Hancock County, Iowa.

Collins, G. B. 1968. From a core of Little Miller's Bay (Lake West Okoboji), Dickinson County, Iowa.

Drum, R. W. 1964. From the Des Moines River, Iowa.

Ehrenberg, C. G. 1856. From the Mississippi River near Burlington, Des Moines County, Iowa, and from the Des Moines River near Fort Dodge, Webster County, Iowa.

Fee, E. J. 1967. From Dutch Creek, Jones County, Iowa.

Gudmundson, B. J. R. 1969. From the plankton of the upper Des Moines River, Iowa.

Gudmundson, B. J. R. 1972. From the plankton of the upper Des Moines River, Iowa.

Hungerford, J. J. 1972. From Pillsbury Lake bed, Dickinson County, Iowa.

Lowe, R. L. 1970. From drainage ditches, Story County, Iowa.

Lowe, R. L. 1972b. From drainage ditches, Story County, Iowa.

Myers, P. C. 1898b. From fossil diatomaceous earth, Muscatine County, Iowa. (cited as *Navicula borealis* (Ehr.) Kuetz.)

Ohl, L. E. 1965. From various farm ponds, Iowa.

Stoermer, E. F. 1963. From Lake West Okoboji, Dickinson County, Iowa.

Pinnularia borealis var. *brevicostata* Hust.

Reported by: Reimer, C. W. 1970. From Cayler Prairie, Dickinson County, Iowa.

Pinnularia borealis var. *congolensis* Zanon

Reported by: Christensen, C. L. 1976. From Dead Man's Lake, Hancock County, Iowa.

Pinnularia borealis var. *rectangularis* Carlson

Reported by: Christensen, C. L. 1976. From Dead Man's Lake, Hancock County, Iowa.

Hungerford, J. J. 1972. From Pillsbury Lake bed, Dickinson County, Iowa.

Pinnularia borealis var. *rectangulata* Hust.

Reported by: Ohl, L.E. 1965. From a farm pond, Warren County, Iowa.

Pinnularia braunii var. *amphicephala* (Mayer) Hust.

Reported by: Drum, R. W. 1964. From the Des Moines River, Iowa.

Ohl, L. E. 1965. From three farm ponds, Warren and Story Counties, Iowa.

Pinnularia braunii (Grun.) Cl. var. *braunii*

Reported by: Christensen, C. L. 1976. From Dead Man's Lake, Hancock County, Iowa.

Ohl, L. E. 1965. From a farm pond, Warren County, Iowa.

<u>Pinnularia</u> <u>brebissonii</u> fo. <u>biundulata</u> (O. Müller) Cleve-Euler

Reported by: Begres, F. M. 1971. From the plankton of Ventura Marsh, Cerro Gordo and Hancock Counties, Iowa.

<u>Pinnularia</u> <u>brebissonii</u> (Kütz.) Rabh. var. <u>brebissonii</u>

Reported by: Begres, F. M. 1971. From Clear Lake and Ventura Marsh, Cerro Gordo and Hancock Counties, Iowa.

Collins, G. B. 1968. From cores of Little Miller's Bay (Lake West Okoboji) and of the Arend's Kettle Hole, Dickinson County, Iowa.

Edwards, M. L. 1974. From a drainage tile near Big Spirit Lake, Dickinson County, Iowa.

Edwards, M., and C. L. Christensen. 1972. From Brewer's Creek, Hamilton County, Iowa.

Fee, E. J. 1967. From Dutch Creek, Jones County, Iowa.

Gudmundson, B. J. R. 1969. From the plankton of the upper Des Moines River, Iowa.

Gudmundson, B. J. R. 1972. From the plankton of the upper Des Moines River, Iowa.

Krohn, M., M. Edwards, and J. D. Dodd. 1974. From Big Spirit Lake, Dickinson County, Iowa.

Lowe, R. L. 1970. From drainage ditches, Story County, Iowa.

Lowe, R. L. 1972b. From drainage ditches, Story County, Iowa.

Ohl, L. E. 1965. From various farm ponds, Iowa. (cited as <u>Pinnularia</u> <u>brebissonii</u> (Kütz.) Cl.)

Roeder, D. R. 1976. From the Skunk River, Story County, Iowa.

Schmidt, D. J., and E. J. Fee. 1967. From the plankton of the Coralville Reservoir, Johnson County, Iowa.

Starrett, W. C., and R. Patrick. 1952. From two samples of benthic material from the Des Moines River, Boone County, Iowa. (cited as _Pinnularia_ _brebissonii_ Rabh.)

Stoermer, E. F. 1963. From Lake West Okoboji, Dickinson County, Iowa. (cited as _Pinnularia_ _microstauron_ var. _brebissonii_ A. Mayer)

Volker, R. P. 1963. From the plankton of Lake East Okoboji, Dickinson County, Iowa. (cited as _Pinnularia_ _microstauron_ var. _brebissonii_ (Kütz.) Hust.)

Pinnularia _brebissonii_ var. _diminuta_ (Grun.) Cl.

Reported by: Reimer, C. W. 1970. From a soil sample at Cayler Prairie, Dickinson County, Iowa.

Pinnularia _brevicostata_ Cl. var. _brevicostata_

Reported by: Begres, F. M. 1971. From Clear Lake, Cerro Gordo County, Iowa.

Christensen, C. L. 1976. From Dead Man's Lake, Hancock County, Iowa.

Collins, G. B. 1968. From a core of the Arend's Kettle Hole, Dickinson County, Iowa.

Pinnularia _clevei_ Patr. var. _clevei_

Reported by: Hungerford, J. J. 1972. From Pillsbury Lake bed, Dickinson County, Iowa.

Pinnularia _crucifera_ var. _elongata_ A. Cl.

Reported by: Christensen, C. L. 1976. From Dead Man's Lake, Hancock County, Iowa.

<u>Pinnularia</u> <u>dicephala</u> (Ehr.) W. Sm. var. <u>dicephala</u>

Reported by: Ehrenberg, C. G. 1856. From the Des Moines River near Fort Dodge, Webster County, Iowa.

<u>Pinnularia</u> <u>doloma</u> Hohn and Hellerman var. <u>doloma</u>

Reported by: Ohl, L. E. 1965. From a farm pond, Clarke County, Iowa.

<u>Pinnularia</u> <u>fasciata</u> Lagerstedt var. <u>fasciata</u>

Reported by: Volker, R. P. 1963. From the plankton of Lake East Okoboji, Dickinson County, Iowa.

<u>Pinnularia</u> <u>flexuosa</u> Cl. var. <u>flexuosa</u>

Reported by: Christensen, C. L. 1976. From Dead Man's Lake, Hancock County, Iowa.

Lowe, R. L. 1970. From a drainage ditch, Story County, Iowa.

Lowe, R. L. 1972a. From a drainage ditch, Story County, Iowa.

Lowe, R. L. 1972b. From a drainage ditch, Story County, Iowa.

<u>Pinnularia</u> <u>fluminea</u> Patr. var. <u>fluminea</u>

Reported by: Lowe, R. L. 1972a. From a drainage ditch, Story County, Iowa.

<u>Pinnularia</u> <u>gastrum</u> Ehr. var. <u>gastrum</u>

Reported by: Ehrenberg, C. G. 1856. From the Des Moines River near Fort Dodge, Webster County, Iowa.

<u>Pinnularia</u> <u>gentilis</u> (Donk.) Cl. var. <u>gentilis</u>

Reported by: Christensen, C. L. 1976. From Dead Man's Lake, Hancock County, Iowa.

Stoermer, E. F. 1963. From Lake West Okoboji, Dickinson County, Iowa.

<u>Pinnularia</u> <u>gibba</u> fo. <u>constricta</u> Skv.

Reported by: Ohl, L. E. 1965. From a farm pond, Adams

County, Iowa.

<u>Pinnularia</u> <u>gibba</u> Ehr. var. <u>gibba</u>

Reported by: Christensen, C. L. 1976. From Dead Man's Lake, Hancock County, Iowa.

Myers, P. C. 1898b. From fossil diatomaceous earth, Muscatine County, Iowa. (cited as <u>Navicula</u> <u>gibba</u> (Ehr.) Kütz.)

Stoermer, E. F. 1963. From Lake West Okoboji, Dickinson County, Iowa.

<u>Pinnularia</u> <u>gibba</u> var. <u>sancta</u> Grun.

Reported by: Christensen, C. L. 1976. From Dead Man's Lake, Hancock County, Iowa.

<u>Pinnularia</u> <u>gibba</u> fo. <u>subundulata</u> Mayer

Reported by: Christensen, C. L. 1976. From Dead Man's Lake, Hancock County, Iowa. (cited as <u>Pinnularia</u> <u>gibba</u> fo. <u>subundulata</u> A. Mayer <u>ex</u> Hust.)

Lowe, R. L. 1970. From two drainage ditches, Story County, Iowa.

Lowe, R. L. 1972a. From drainage ditches, Story County, Iowa.

Lowe, R. L. 1972b. From two drainage ditches, Story County, Iowa.

<u>Pinnularia</u> <u>gracilis</u> Hust. var. <u>gracilis</u>

Reported by: Lowe, R. L. 1970. From two drainage ditches, Story County, Iowa.

Lowe, R. L. 1972a. From a drainage ditch, Story County, Iowa.

Lowe, R. L. 1972b. From two drainage ditches, Story County, Iowa.

<u>Pinnularia</u> <u>hilseana</u> Jan. var. <u>hilseana</u>

Reported by: Lowe, R. L. 1970. From a drainage ditch, Story County, Iowa.

Lowe, R. L. 1972b. From a drainage ditch, Story County, Iowa.

Pinnularia inaequalis Ehr. var. *inaequalis*

Reported by: Ehrenberg, C. G. 1856. From the Des Moines River near Fort Dodge, Webster County, Iowa.

Pinnularia intermedia (Lagerst.) Cl. var. *intermedia*

Reported by: Drum, R. W. 1964. From the Des Moines River, Iowa.

Fee, E. J. 1967. From Dutch Creek, Jones County, Iowa.

Stoermer, E. F. 1963. From Lake West Okoboji, Dickinson County, Iowa.

Pinnularia interrupta W. Sm. var. *interrupta*

Reported by: Drum, R. W. 1964. From the Des Moines River, Iowa.

Ohl, L. E. 1965. From a farm pond, Warren County, Iowa.

Starrett, W. C., and R. Patrick. 1952. From the Des Moines River, Boone County, Iowa. (cited as *Pinnularia interrupta* Rabh.)

Pinnularia interrupta fo. *minutissima* Hust.

Reported by: Christensen, C. L. 1976. From Dead Man's Lake, Hancock County, Iowa.

Pinnularia interrupta fo. *stauroneiformis* Cl.

Reported by: Ohl, L. E. 1965. From a pond, Warren County, Iowa.

Pinnularia iridis (Nitz.) Ehr. var. *iridis*

Reported by: Edwards, M., and C. L. Christensen. 1972. From Brewer's Creek, Hamilton County, Iowa.

Pinnularia karelica Cl. var. karelica

Reported by: Drum, R. W. 1964. From the Des Moines River, Iowa.

Pinnularia kneuckeri Hust. var. kneuckeri

Reported by: Begres, F. M. 1971. From Ventura Marsh, Cerro Gordo and Hancock Counties, Iowa.

Collins, G. B. 1968. From a core of Little Miller's Bay (Lake West Okoboji), Dickinson County, Iowa.

Stoermer, E. F. 1963. From Lake West Okoboji, Dickinson County, Iowa.

Pinnularia lata (Bréb.) Rabh. var. lata

Reported by: Dodd, J. D., and E. F. Stoermer. 1962. From Ledges State Park, Boone County, Iowa. (cited as Pinnularia lata Breb.)

Pinnularia legumen Ehr. var. legumen

Reported by: Christensen, C. L. 1976. From Dead Man's Lake, Hancock County, Iowa. (cited as Pinnularia legumen (Ehr.) Ehr.)

Hungerford, J. J. 1972. From Pillsbury Lake bed, Dickinson County, Iowa.

Pinnularia macilenta Ehr. var. macilenta

Reported by: Ehrenberg, C. G. 1856. From the Mississippi River near Burlington, Des Moines County, Iowa, and from the Des Moines River near Fort Dodge, Webster County, Iowa.

Pinnularia maior (Kütz.) Rabh. var. maior

Reported by: Christensen, C. L. 1976. From Dead Man's Lake, Hancock County, Iowa.

Fee, E. J. 1967. From Dutch Creek, Jones County, Iowa. (cited as Pinnularia maior (Kütz.) Cl.)

Hungerford, J. J. 1971. From the West Branch of Big Cedar Creek, Pocahontas County, Iowa.

Kutkuhn, J. H. 1958. From North Twin Lake, Calhoun County, Iowa. (cited as Pinnularia major Kütz.)

Myers, P. C. 1898b. From fossil diatomaceous earth, Muscatine County, Iowa. (cited as Navicula major Kuetz.)

Ohl, L. E. 1965. From some ponds, Iowa. (cited as Pinnularia major (Kütz.) Cl.)

Stoermer, E. F. 1963. From Lake West Okoboji, Dickinson County, Iowa. (cited as Pinnularia major (Kütz.) Cl.)

Pinnularia maior var. pulchella Boyer

Reported by: Christensen, C. L. 1976. From Dead Man's Lake, Hancock County, Iowa.

Pinnularia maior var. transversa (A.S.) Cl.

Reported by: Christensen, C. L. 1976. From Dead Man's Lake, Hancock County, Iowa.

Ohl, L. E. 1965. From two farm ponds, Warren and Clarke Counties, Iowa.

Pinnularia mesogongyla Ehr. var. mesogongyla

Reported by: Christensen, C. L. 1976. From Dead Man's Lake, Hancock County, Iowa.

Pinnularia mesolepta (Ehr.) W. Sm. var. mesolepta

Reported by: Christensen, C. L. 1976. From Dead Man's Lake, Hancock County, Iowa.

Pinnularia mesolepta var. stauroneiformis (Grun.) Cl.

Reported by: Ohl, L. E. 1965. From a farm pond, Boone County, Iowa.

Pinnularia mesolepta var. turbulenta Cl-Euler

Reported by: Christensen, C. L. 1976. From Dead Man's Lake, Hancock County, Iowa.

Pinnularia microstauron fo. diminuta Grun.

Reported by: Christensen, C. L. 1976. From Dead Man's Lake, Hancock County, Iowa.

Pinnularia microstauron (Ehr.) Cl. var. microstauron

Reported by: Christensen, C. L. 1976. From Dead Man's Lake, Hancock County, Iowa.

Drum, R. W. 1964. From the Des Moines River, Iowa.

Gudmundson, B. J. R. 1969. From the upper Des Moines River, Iowa.

Gudmundson, B. J. R. 1972. From the upper Des Moines River, Iowa.

Hayek, J. W., and R. L. Hulbary. 1956. From a soil sample taken near Iowa City, Iowa.

Hungerford, J. J. 1972. From Pillsbury and Sylvan Lake beds, Dickinson County, Iowa.

Reimer, C. W. 1970. From a soil sample from Cayler Prairie, Dickinson County, Iowa.

Stoermer, E. F. 1962. From South Falls, Marion County, Iowa.

Stoermer, E. F. 1963. From Lake West Okoboji, Dickinson County, Iowa.

Pinnularia molaris (Grun.) Cl. var. molaris

Reported by: Christensen, C. L. 1976. From Dead Man's Lake, Hancock County, Iowa.

Volker, R. P. 1963. From Lake East Okoboji, Dickinson County, Iowa.

<u>Pinnularia</u> <u>nobilis</u> var. <u>dactylus</u> (Ehr.) V.H.

Reported by: Myers, P. C. 1898b. From fossil diatomaceous earth, Muscatine County, Iowa.

<u>Pinnularia</u> <u>nobilis</u> (Ehr.) Ehr. var. <u>nobilis</u>

Reported by: Christensen, C. L. 1976. From Dead Man's Lake, Hancock County, Iowa.

Myers, P. C. 1898a. From Clear Lake, Cerro Gordo County, Iowa. (cited as <u>Navicula</u> <u>nobilis</u>)

<u>Pinnularia</u> <u>nodosa</u> (Ehr.) W. Sm. var. <u>nodosa</u>

Reported by: Begres, F. M. 1971. From Ventura Marsh, Cerro Gordo and Hancock Counties, Iowa.

Christensen, C. L. 1976. From Dead Man's Lake, Hancock County, Iowa.

<u>Pinnularia</u> <u>obscura</u> Krasske var. <u>obscura</u>

Reported by: Collins, G. B. 1968. From a core of Little Miller's Bay (Lake West Okoboji), Dickinson County, Iowa.

Drum, R. W. 1964. From the Des Moines River, Iowa.

Fee, E. J. 1967. From Dutch Creek, Jones County, Iowa.

Ohl, L. E. 1965. From two farm ponds, Clarke and Story Counties, Iowa.

<u>Pinnularia</u> <u>rupestris</u> Hantz. var. <u>rupestris</u>

Reported by: Gudmundson, B. J. R. 1969. From the upper Des Moines River, Iowa.

Gudmundson, B. J. R. 1972. From the upper Des Moines River, Iowa.

Myers, P. C. 1898b. From fossil diatomaceous earth, Muscatine County, Iowa. (cited as <u>Navicula</u> <u>rupestris</u> (Pinn.) Hantz.)

Pinnularia ruttneri Hust. var. ruttneri

Reported by: Begres, F. M. 1971. From Clear Lake, Cerro Gordo County, Iowa.

Christensen, C. L. 1976. From Dead Man's Lake, Hancock County, Iowa.

Reimer, C. W. 1970. From a soil sample and a plankton sample at Cayler Prairie, Dickinson County, Iowa.

Pinnularia stomatophora (Grun.) Cl. var. stomatophora

Reported by: Christensen, C. L. 1976. From Dead Man's Lake, Hancock County, Iowa.

Collins, G. B. 1968. From a core of Little Miller's Bay (Lake West Okoboji), and from a core of the Arend's Kettle Hole, Dickinson County, Iowa.

Shobe, W. R., E. F. Stoermer, and J. D. Dodd. 1963. From Excelsior Fen, Dickinson County, Iowa. (cited as Pinnularia stomatophora Grun.)

Stoermer, E. F. 1963. From Lake West Okoboji, Dickinson County, Iowa.

Pinnularia stomatophora var. triundulata Font.

Reported by: Ohl, L. E. 1965. From three farm ponds, Iowa.

Pinnularia streptoraphe Cl. var. streptoraphe

Reported by: Christensen, C. L. 1976. From Dead Man's Lake, Hancock County, Iowa.

Collins, G. B. 1968. From a core of the Arend's Kettle Hole, Dickinson County, Iowa.

Hungerford, J. J. 1972. From Pillsbury Lake bed, Dickinson County, Iowa.

Lowe, R. L. 1970. From a drainage ditch, Story County, Iowa.

Lowe, R. L. 1972a. From a drainage ditch, Story County, Iowa.

Lowe, R. L. 1972b. From a drainage ditch, Story County, Iowa.

Pinnularia stricta Hust. var. stricta

Reported by: Collins, G. B. 1968. From a core of the Arend's Kettle Hole, Dickinson County, Iowa.

Pinnularia subcapitata var. paucistriata (Grun.) Cl.

Reported by: Hungerford, J. J. 1972. From Pillsbury Lake bed, Dickinson County, Iowa.

Pinnularia subcapitata Greg. var. subcapitata

Reported by: Christensen, C. L. 1976. From Dead Man's Lake, Hancock County, Iowa.

Collins, G. B. 1968. From a core of the Arend's Kettle Hole, Dickinson County, Iowa.

Shobe, W. R., E. F. Stoermer, and J. D. Dodd. 1963. From Excelsior Fen, Dickinson County, Iowa.

Pinnularia subsolaris (Grun.) Cl. var. subsolaris

Reported by: Ohl, L. E. 1965. From two farm ponds, Boone and Story Counties, Iowa.

Pinnularia substomatophora Hust. var. substomatophora

Reported by: Begres, F. M. 1971. From Ventura Marsh, Cerro Gordo and Hancock Counties, Iowa.

Ohl, L. E. 1965. From a farm pond, Boone County, Iowa.

Pinnularia titusiana Hagelstein var. titusiana

Reported by: Lowe, R. L. 1972a. From a drainage ditch, Story County, Iowa.

Pinnularia torta (Mann.) Patr. var. torta

Reported by: Lowe, R. L. 1970. From a drainage ditch, Story County, Iowa.

Lowe, R. L. 1972a. From a drainage ditch, Story County, Iowa.

Lowe, R. L. 1972b. From a drainage ditch, Story County, Iowa.

Pinnularia _viridis_ var. _commutata_ (Grun.) Cl.

Reported by: Christensen, C. L. 1976. From Dead Man's Lake, Hancock County, Iowa.

Hungerford, J. J. 1972. From Pillsbury Lake bed, Dickinson County, Iowa.

Pinnularia _viridis_ var. _intermedia_ Cl.

Reported by: Begres, F. M. 1971. From Ventura Marsh, Cerro Gordo and Hancock Counties, Iowa, and Clear Lake, Cerro Gordo County, Iowa.

Christensen, C. L. 1976. From Dead Man's Lake, Hancock County, Iowa.

Pinnularia _viridis_ var. _minor_ Cl.

Reported by: Reimer, C. W. 1970. From a soil sample from Cayler Prairie, Dickinson County, Iowa.

Roeder, D. R. 1976. From the Skunk River, Story County, Iowa.

Shobe, W. R. 1967. From the Skunk River, Story County, Iowa.

Pinnularia _viridis_ (Nitz.) Ehr. var. _viridis_

Reported by: Beckert, C. A. 1977. From the Skunk River, Story County, Iowa.

Begres, F. M. 1971. From Ventura Marsh, Cerro Gordo and Hancock Counties, Iowa, and from Clear Lake, Cerro Gordo County, Iowa.

Christensen, C. L. 1976. From Dead Man's Lake, Hancock County, Iowa.

Collins, G. B. 1968. From a core of the Arend's Kettle Hole, Dickinson County, Iowa.

Drum, R. W. 1964. From the Des Moines River, Iowa.

Edwards, M. L. 1974. From drainage tiles near Big Spirit Lake, Dickinson County, Iowa.

Ehrenberg, C. G. 1856. From the Des Moines River near Fort Dodge, Webster County, Iowa.

Fee, E. J. 1967. From Dutch Creek, Jones County, Iowa.

Hungerford, J. J. 1972. From Pillsbury and Sylvan Lake beds, Dickinson County, Iowa.

Krohn, M., M. Edwards, and J. D. Dodd. 1974. From Big Spirit Lake, Dickinson County, Iowa.

Lowe, R. L. 1970. From three drainage ditches, Story County, Iowa.

Lowe, R. L. 1972b. From three drainage ditches, Story County, Iowa.

Ohl, L. E. 1965. From various farm ponds, Iowa. (cited as *Pinnularia viridis* Ehr.)

Reimer, C. W. 1970. From a soil sample from Cayler Prairie, Dickinson County, Iowa.

Roeder, D. R. 1976. From the Skunk River, Story County, Iowa.

Shobe, W. R., E. F. Stoermer, and J. D. Dodd. 1963. From Excelsior Fen, Dickinson County, Iowa.

Starrett, W. C., and R. Patrick. 1952. From the Des Moines River, Boone County, Iowa. (cited as *Pinnularia viridis* Ehr.)

Stoermer, E. F. 1963. From Lake West Okoboji, Dickinson County, Iowa. (cited as *Pinnularia viridis* Ehr.)

Volker, R. P. 1963. From Lake East Okoboji, Dickinson County, Iowa.